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Structure, nature and determinants of international production networks in East Asia the automobile industry

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STRUCTURE, NATURE AND DETERMINANTS OF INTERNATIONAL PRODUCTION NETWORKS IN EAST ASIA: THE AUTOMOBILE INDUSTRY

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
AFTA	ASEAN Free Trade Agreement
AICO	ASEAN Industrial Cooperation
AL	accuracy level
APEC	Asia-Pacific Economic Corporation
ASEAN	Association of Southeast Asian Nations
ASEAN+3	ASEAN + Japan, Korea and China
BEC	Broad Economic Categories
BNA	Binary Network Analysis
CEPT	Common Effective Preferential Tariff
CER	Closer Economic Relation
CES	constant elasticity of substitution
CIF	Cost Insurance and Freight
CKD	Complete Knock Down
DDI	domination degree index
DEA	developing East Asia
DII	domination intensity index
EOI	export orientation industrialization
EPA	Economic Partnership Agreement
ESCAP	Economic and Social Commission for Asia and the Pacific
EU	European Union
FG	final goods
FOB	Free on board
FTA	Free Trade Agreement
GDP	Gross Domestic Product
GTAP	Global Trade Analysis Project
HS	Harmonised System
ICI	International Competitiveness Index
ICT	Information and Communication Technologies
IMF	International Monetary Fund
IPNs	International production networks
ISI	import substitution industrialization
IV	Instrumental Variable
LSDV	Least Squares Dummy Variable
MII	Import Intensity Index
MNCs	multinational corporations
MSI	Import Share Index
NAFTA	North American Free Trade Agreement
ND	Network density
NDC	Node degree centrality
NEG	new economic geography
NIEs	Asia's New Industrial Economies
NSC	Node strength centrality
NSC	node strength centrality
OECD	Organization for Economic Co-operation and Development
OEMs	Original Equipment Manufacturers
OLS	Ordinary Least Squares
P&C	parts and components
PRC	People's Republic of China
RIM	importer-commodity reliability index
RIX	exporter-commodity reliability index
ROW	rest of the world

SITC	Standard International Trade Classification
STM	Siam Toyota Manufacturing
TABT	Toyota Auto Body
TAP	Toyota Auto Parts Philippines Inc.
UN	United Nation
USA	United State of America
USSR	Union of Soviet Socialist Republics
VAL	the largest value-weighted accuracy level for both importer and exporter
VIF	variance inflation factor
WNA	Weighted network analysis
WTO	World Trade Organisation
XII	Export Intensity Index
XSI	Export Share Index

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DECLARATION

I declare that I am the author of this thesis and I have consulted all the references cited. All the work of which this thesis is a record has been done by myself and has not been previously accepted for a higher degree. All the tables and figures, unless otherwise stated, are a source of my own calculations.

Signed

Shahrun Nizam Abdul Aziz, PhD Candidate

Date: 02/04/2016

CERTIFICATION

I certify that Mr. Shahrun Nizam Abdul Aziz conducted his research under my supervision in the Department of Economic Studies, University of Dundee. Mr. Shahrun Nizam Abdul Aziz has fulfilled all the conditions of the relevant Ordinances and Regulations of the University of Dundee for obtaining the Degree of Doctor of Philosophy.

Signed……

Professor Paul Allanson

1st Supervisor

Date…….

ABSTRACT

The objective of this thesis is to make a contribution to the existing knowledge and understanding of the structure, nature and determinants of East Asia's automobile production networks. To understand the structure of East Asia's automobile production, we explored the trade networks in terms of the major roles played by each East Asian country, their main trading partners, and the network patterns for the years 1990, 1995, 2000, 2005 and 2010. After understanding the structure of East Asia's production networks, we then explored the nature of such networks by means of some related indices. Consequently, through the use of gravity equations, we were able to investigate the determinants of the automobile trade level for East Asian countries given their position in the international production networks.

The findings of this thesis indicate that East Asia's automobile networks are expanding over time and there exists a trend toward exporting parts and components for domestic assembly in view of the local market. In terms of the production network, the role of some countries such as Malaysia and Singapore remains unchanged, while the role of other countries such as China, Indonesia and the Philippines had expanded from importers to exporters of auto parts and components. Meanwhile, the role of Thailand has changed dramatically during the same period, i.e. from an importer of auto parts, components and final automobiles in the 1990s to an exporter of auto parts, components and final automobiles in the decade that followed. The findings also suggested that the main actor, i.e. Japan, played a major role in the transformation of the auto industry in East Asia during this period, with it now importing auto parts and components from its East Asian partners and also exporting auto parts and components to Thailand which then exports them as final goods. In addition, IPNs structure and nature, government policies as well as the role played by Japanese MNCs are the important determinants that boosted the development of East Asia's auto industry.

CHAPTER 1: INTRODUCTION

1.1 Study Background

International production networks (IPNs) have become a key feature in the ongoing process of globalisation. In the literature, it has been defined as the organisation of the production process by firms into multiple stages, and while each stage may be found in different countries with costs advantage, all ultimately lead to the same final product(s)[1]. There are many examples of IPNs which one can find in a number of industries. For instance, in the computer industry, a so-called Chinese-made Lenovo laptop is assembled into a recognizable computer in China, even though parts and components (P&C) of that machine were produced in other countries. The hard drive was produced in Singapore, the motherboard in Japan, the memory in the Republic of Korea, the display panel in Taiwan, and the microprocessor in Malaysia.

Ever since IPN was first identified in the early 1990s, the phenomenon has continued to develop across both space and time. In its early stage, IPN was only noticeable in the electronics and clothing industries, but over time it has spread to many other industries such as automobile, sports footwear, office equipment, camera and watches, etc. (Athukorala, 2010). At the same time, the participation of countries in IPNs has also increased over time. In addition, the phenomenon has been developed

[1]Different terminologies have been used by different authors when discussing IPNs. For example, "intra-product specialisation" or "super-specialisation" has been used by Arndt (1998), "international production/distribution network" has been used by Kimura et al. (2006, 2007), "international production fragmentation" has been used by Formentini and Iapadre (2008), "global value chain" has been used by Lim and Kimura (2010) and Sturgeon (2013), "global production networks" has been used by Henderson et al. (2002) and also by Fleischmann et al. (2006), and "vertical specialisation" has been used by Hummels et al. (1998, 2001), Yi (2003) and Amador and Cobral (2008).

by means of three different phases. In the first phase, developed countries would move a small part of the production process to a low-cost developing country and then re-import those assembled components to be incorporated in the final product. In the second phase, countries' participation in IPNs has increased, wherein each of them would specialise at different stages of the production process. In this respect, a product normally crosses many countries before it becomes a finished product. In the third phase, manufacturers in developed countries start to shift their final assembly of many consumer durable products (such as automobiles, computers, television, and cameras) abroad in order to take advantage of low-cost labour and/or to be closer to the markets (Athukorala 2010).

1.2 Motivation of the study

Many authors such as Hiratsuka (2011), Athukorala and Yamashita (2006), Kimura et al. (2006, 2007) have argued that trade in parts and component products has grown significantly, surpassing trade in final products. Tables 1.1 and 1.2 respectively lay out East Asia's exports and imports of machinery P&C and final machinery products between 1990 and 2010[2]. Based on those figures, exports of machinery P&C increased almost eightfold between 1990 and 2010 (i.e., from US$ 63.2 billion to US$ 487.4 billion), while exports in final machinery products increased about six fold (i.e., from US$ 209.4 billion to US$ 1.4 trillion). At the same time, imports of machinery P&C increased nearly six fold, which is greater than increase in the imports of final machinery products for the same period. Among East Asian countries, China recorded the highest growth in exports and imports of machinery P&C. Between 1990 and 2000, China has achieved growth in exports and imports of

[2]We follow Kimura (2007) when it comes to classifying machinery P&C and final machinery products.

machinery P&C of well over 90-fold and 11-fold, respectively. The second highest in terms of growth in imports of machinery P&C within the same period was ASEAN. Apart from that, IPNs have also strengthened economic interdependence among countries in the East Asian region (Athukorala, 2010).

Table 1.1: East Asia's Trade in Machinery P&C between 1990 and 2010 (US$ billions)

Country	Exports			Imports		
	1990	**2000**	**2010**	**1990**	**2000**	**2010**
Japan	47.1	86.4	109.5	9.4	31.8	36.6
Rep. of Korea	3.6	22.6	69.6	5.9	14.2	27.1
China	2.4	38.0	222.6	8.9	25.1	97.6
ASEAN	10.1	59.8	85.7	34.6	69.2	167.2
East Asia	63.2	206.8	487.4	58.8	140.2	324.6

Source: Author's calculation based on UN Comtrade data.

Table 1.2: East Asia's Trade in Final Machinery Products between 1990 and 2010 (US$ billions)

Country	Exports			Imports		
	1990	**2000**	**2010**	**1990**	**2000**	**2010**
Japan	146.3	244.6	329.7	35.8	83.4	117.5
Rep. of Korea	19.6	65.9	160.9	17.1	44.7	84.1
China	15.0	118.2	626.3	11.5	46.9	138.3
ASEAN	28.5	149.4	288.5	41.5	125.5	240.4
East Asia	209.4	578.1	1405.4	105.9	300.5	580.3

Source: Author's calculation based on UN Comtrade data.

Meanwhile, Table 1.3 depicts East Asian countries' share of the total world trade in P&C. This shows that East Asia's share in terms of total global exports of P&C increased from 29.6 percent in 1992/3 to 43.8 percent in 2006/7. At the same time, East Asia's share in the total global imports of P&C also increased from 30.1 percent to 36.6 percent during the same period. Moreover, almost all countries in the region experienced an increase in their share of total global trade in P&C, and once again China experienced the most significant increase in this regard. The significant increase in trade in machinery P&C has contributed to an increasing share of the overall machinery trade between 1990 and 2010, which might be seen as a distinguishing characteristic in the growth of IPNs. Given the notable increase in

IPNs in the East Asian region, coupled with the rapid increase in intermediate trade, the study of IPNs has no doubt become an important research topic for the region.

Table 1.3: Share of East Asian Countries in Total World Trade of Machinery P&C between 1992/3 and 2006/7

Country	Exports (%)		Imports (%)	
	1992/3	**2006/7**	**1992/3**	**2006/7**
Japan	15.2	9.1	4.0	3.8
Republic of Korea	2.2	5.6	3.1	2.5
China	1.7	13.5	3.0	11.5
Thailand	0.6	1.4	2.0	1.4
Indonesia	0.1	0.5	1.1	0.3
The Philippines	0.5	1.8	0.6	1.2
Malaysia	1.7	3.4	3.0	2.4
Singapore	2.3	2.6	4.8	4.5
Vietnam	0.0	0.1	0.0	0.3
East Asia	29.6	43.8	30.1	36.6

Source: Athukorala and Yamashita (2010)

Even though East Asia's IPNs continue to grow and have a significant effect on trade level as well as development of many countries in the region, many authors such as Hiratsuka (2008), as well as Kimura and Obashi (2011) have argued that we still do not know well enough about the overall picture, nature and characteristics of this phenomenon, such that further research into the phenomenon is needed. In terms of trade structure, previous studies have provided a general picture of the pattern of IPNs in East Asia. For example, Hummels et al. (2001) have highlighted the existence of vertical specialisation across countries whereby imported intermediate goods have been used to produce products that are subsequently exported. In this respect, each country specialises in particular stages of a product's production chain. Besides, Kimura et al. (2006) and Kimura et al. (2007) also pointed out that intra-industry trade between East Asian countries is "vertical", while trade between developed countries such as the core EU member-countries is "horizontal". Meanwhile, Okomoto (2005) has outlined the various roles played by East Asian countries in industries such as textiles, metals, chemicals, electrics machinery, and

transport machinery. To my knowledge, none of the past studies has focused on formally identifying the position of individual countries within a vertical production chain.

For the above reasons, this thesis intends to study East Asia's IPNs with a specific focus on the automobile industry. This industry has been chosen because: (1) its importance to the countries/region; (2) the developed nature of IPNs within the automobile industry. As to the first reason, this industry has played an important role in stimulating exports and economic growth, contributing to employment, as well as reducing poverty in the East Asian region (Dicken, 2003; Nag et al., 2007). As to the second reason, East Asia's automobile industry has experienced a noticeable increase in production network trade compared to other industries such as textiles (Orefice and Rocha, 2014). This is because the automobile industry has a large number of downstream and upstream businesses and they disseminate across the region (Fuangkajonsak, 2006). This situation, in turn, leads to the development of industrialization in both developed and developing countries in East Asia.

1.3 Objectives and contributions of the study

The objective of this thesis is to contribute to the existing understanding and knowledge about structure, nature and determinants of East Asia's IPNs, with a specific focus on the automobile industry. Firstly, this thesis aims to develop methods for identifying the structure of IPNs in industries characterised by vertical specialisation, whereby it aims to build on previous works in order to identify patterns of development (flying geese, spiral development patterns) in relation to previous theories of international trade and specialisation (for example, Okamoto,

2005). In particular, the growing importance of P&C trade implies that such patterns are most appropriately identified through the analysis of trade data, superseding earlier methodologies by developing new methods. By using these new methods, one is able to acquire a readable structure of vertical relationships among East Asia's automobile production networks. In this respect, information such as countries that participate actively in IPNs, upstream and downstream countries in IPNs, and the development of trade networks brought about by IPNs will thus be exposed. In addition, such information might enable each country's policy makers to formulate appropriate policies, given their respective roles in IPNs.

A further objective is to develop accompanying summary measures of the characteristics of IPN networks so as to allow for the characterisation of the nature and development of these networks over time. Again, we build on existing works on the construction of indices of network connectivity, complexity and dominating power. By using those indices, one is able to gauge the complexity of a network and how it has evolved over time. In addition, the main actor(s) who played a key role in shaping the network as well as the dominating and dominated country in a network will also be identified. Finally, the objective of this thesis is to employ these summary measures as additional explanatory variables in augmented gravity models in order to examine the determinants of the level of automobile trade in East Asian countries given their position within IPNs. Information on the impact of those indices on trade can provide guidance regarding the benefit to be gained by countries participating in IPNs. In addition, the effectiveness of the import substitution industrialisation (ISI) policy and export orientation industrialisation (EOI) policy as well as the effect of Japanese FDI outflows on developing East Asia (DEA).

1.4 Outline

The thesis is organised as follows. Chapter 2 comprises three main sections. The first is a review of the development of trade and trade policies in East Asia. The second discusses some theories related to the IPNs (i.e., international trade theories, foreign direct investment theories and the concept of international division of labour). The third section discusses a number of related empirical studies.

Chapter 3 focuses on the issues related to the use of UN Comtrade data which are used in the empirical analysis. This chapter describes the source of data, product classifications, and the definition for P&C and final goods. It also presents (based on tables) the problem of inconsistency with regard to the reported data from the UN Comtrade. Moreover, this chapter discusses the process of data reconciliation based on procedure by Gehlhar (1996). Apart from that, this chapter also provides and discusses several selected results from the reconciliation process.

Chapter 4 provides the methodologies for exploring the structure of East Asia's automobile production networks based on the roles played by East Asian countries. In this chapter, we developed an Export Intensity Index (XII) and an Import Intensity Index (MII) to examine the role played by each country, while an Export Share Index (XSI) and an Import Share Index (MSI) have been developed to examine each country's important trade partners. Consequently, the approach put forward by Piana (2006) is adapted to determine the visual pattern of trade networks between countries. Besides those, this chapter also examines the changes in roles, trade partners and network patterns for the years 1990, 1995, 2000, 2005 and 2010.

Chapter 5 provides summary measures to characterise the nature and development of automobile production networks over time. This chapter presents both a global-level analysis and country-level analysis. The former measures the degree of complexity of automobile production networks, while the latter measures the degree of integration and identifies the main actor(s) in those networks. In addition, this chapter also presents a network domination analysis that measures the dominating power of each country in the networks.

Chapter 6 analyses empirically the factors that determine the level of automobile trade among East Asian countries in view of their position in the international production chain. Initially, this chapter discusses briefly the history and theoretical background of the gravity model. To ascertain the key determinants, this chapter presents and discusses results from the basic specification of gravity model, augmented traditional specification of gravity model, as well as the augmented LSDV specification gravity model. Through the third model, the effects of recent changes in trade structure and nature of East Asia's automobile industry, the effectiveness of the ISI policy and EOI policy as well as the effect of Japanese FDI outflows on DEA's production chain have all been discussed.

The final chapter summarises and discusses the main findings of the thesis in terms of structure, nature and determinants of East Asia's automobile production networks. The chapter then discusses some policy implications and acknowledges some inevitable drawbacks to a thesis of this nature before finally offering some suggestions for further research.

CHAPTER 2 : EAST ASIAN TRADE – A REVIEW

2.1 Introduction

The purpose of this chapter is to review the East Asian trade and how it has evolved in the region since World War II. In addition, we are also interested in discussing the related theories of trade and investment and a certain concept of international division of labour, as well as providing a review of the empirical literature and its principal findings with specific reference to IPNs, more generally as well as East Asia in particular. This chapter is important as it will guide us towards a better understanding of: (1) the evolution of trade patterns between countries in this region; (2) the changes in these countries' trade policies over time; (3) the evolution of interdependent relationships between countries with different levels of development in this region; and (4) the relevant theories that explain the nature and level of trade in this region.

This chapter is divided into five broad sections which are structured as follows: Section 2.2 reviews the development of trade and trade policies in East Asian countries since the Second World War. In this section, we will discuss this issue by dividing the countries of East Asia into four groups, viz., Japan; Asia's New Industrial Economies (NIEs) – which include the Republic of Korea, Taiwan, Hong Kong and Singapore; Southeast Asia (viz. Brunei, Cambodia, East Timor, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam) and China. Section 2.3 summarises the theoretical literature related to the IPNs. That literature concerns the theory of international trade, foreign direct investment

theories and the concept of international division of labour. Section 2.4 summarises the empirical literature related to the IPNs. Section 2.5 concludes this chapter and identifies issues worthy of further investigation.

2.2 The development of trade and trade policies in East Asia

The development of East Asian trade in the aftermath of World War II has varied across countries and time periods. Just after the war's end, some countries started to actively trading with other countries, while the others implemented a closed-door policy. Moreover, trade in some countries particularly developed countries grew faster than other developing countries. In what follows we will discuss chronologically the development of countries' trade due to the policy changes.

2.2.1 Japan

In the case of Japan, one of its strategies after the war was to expand its technology-based industry or the so-called "knowledge intensive" industries (viz. sophisticated, heavy and chemical industry products and software) so as to develop its national economy[3]. To achieve this strategy, Japan had to increase its imports of processed raw materials and metal, particularly from developing Asian countries. In doing so, Japan had been assisting developing Asian countries with their economic development[4] and consequently expanding bilateral trade with them[5]. In the 1970s, the main focus of Japanese economic policy was to develop trade relationships and

[3]During this time, Japan has also faced restricted access over the United States market for products such as textiles, steel, machine tools, automobiles and semiconductors (Satake, 2000).
[4]The willingness of Japan to assist developing Asian with their economic development because she needs relatively developed neighbours who may be more rewarding as trade partners (Jo, 1968).
[5]Japanese aid and investments were the key instruments in helping developing countries upgrade their economy.

consequently expanding trade with developing countries, particularly in the Asian region. As a result, trade with Southeast Asian countries accounted for one-third of its total trade, equalling the value of its trade with the United States (Kojima, 1973).

In the second half of the 1980s, however, there was a substantial rise in the value of the Japanese Yen due to the Plaza Agreement of 1985, a phenomenon that changed the patterns of Japanese trade and FDI[6].The appreciation of the Japanese Yen at that time has resulted in a reduction in the international competitiveness of products manufactured in Japan due to the rising cost of domestic production (Kitagawa, 2008; Yoshitomi, 1996). To overcome this problem, many Japanese manufacturing firms aggressively shifted their operation to other countries with lower production costs, particularly those in the Asian region. Furthermore, at that time many countries in the region began to adopt outward-oriented policies of liberalising trade and FDI. These two situations have led to a relationship of "symbiosis" between Japan and other East Asian countries, where these countries became increasingly important to Japan (Kawai and Urata, 2010) and vice versa. According to Kawai and Urata (2010), between 1985 and 1997 Japanese FDI had expanded to the NIEs, then to the ASEAN-5 (i.e., Singapore, Malaysia, Thailand, Indonesia and the Philippines), and finally to China.

In its relationship with developing East Asian countries, Japanese multinational corporations (MNCs) have developed vertical production networks and vertical supply chains with other East Asian countries in many manufacturing industries (Kimura, 2006) such as automobiles, electronics and other machinery products in

[6]The Plaza Accord, also known as the Plaza Arrangement, refers to the arrangement carried out by governments of the world's five biggest economies (namely, the United States, the United Kingdom, France, West Germany and Japan) to depreciate the US dollar in relation to the German Deutsche Mark and Japanese Yen through currency market intervention.

East Asia. Based on the concept of vertical production networks and vertical supply chains, Japan (which used to export only final products to developing Asian countries) has now become the exporter of P&C to those countries. Several authors, such as Athukorala and Yamashita (2006) as well as Kimura (2006), have also noted that starting from the early 1990s, the growth of trade in P&C in East Asia has exceeded the growth of trade in final goods.

Under the concept of IPNs, Japanese firms have shifted different stages of production to different countries, such that each of these countries has specialised in the production of a specific intermediate or final product. In the automobile industry, for example, some production of the car bodies has been shifted to Thailand, and some of the production of car's transmission have been moved to the Philippines. The changes in trade patterns between Japan and developing Asian countries seem to have set up the East Asian region as some kind of a factory. In this respect, every stage of production is now located in a different country and each country seems to be structured within a hierarchal production chain.

2.2.2 Asia's newly industrial economies (NIEs)

For NIEs, the adoption of an "outward-oriented development Strategy" in the early 1960s led to the rapid expansion of trade in Asian NIEs' economies in the 1970s.Between 1970 and 1981, total exports from this group of countries grew at an average of more than 26 percent per annum, while exports of manufactured products (accounting for 70 percent of their total exports in 1970) were maintained at an annual average rate of growth of 28 percent within the same period (Lee and Naya, 1988). Besides, high growth rate in the NIEs' economies during the 1970s also

stimulated import demand for manufactured and intermediate products. The NIEs relied upon Japan for their sources of capital products, intermediate products, technology and management know-how, even as the important market for their manufactured products was the United States.

In the 1980s, there was a significant change in trade and industrial structures among East Asian countries. The massive appreciation of Japanese Yen since the Plaza Accord of 1985 led to a significant increase in Japan's demand for imported manufactured products, particularly from the Asian NIEs. In addition, protectionist measures directed against Japanese exports by the United States also stimulated Japanese multinationals as well as small and medium-size firms to operate in other Asian countries (Kawai and Urata, 2010). This has resulted in Japanese FDI spreading throughout Asia, particularly in the manufacturing sector. Between 1983 and 1988, Japanese FDI to the Asian NIEs more than doubled, most of which went to the machinery sector (Park and Park, 1991).

Efforts taken by the Asian NIEs, such as educating their citizens to become knowledgeable and skilled workers as well as increasing the value of their products that were being exported, have enhanced their competitiveness. For instance, today we can witness that the Republic of Korea has giant technology firms such as Samsung and LG, while Singapore has become a global trading and banking hub since they have educated and high-skilled workers. The labour costs in these countries have become higher given their level of education and skill which has led to companies having to compete for workers. As a result, many companies in these countries have moved basic manufacturing operations to other countries where labour is cheaper. MNCs from Asian NIEs, particularly from Hong Kong, Singapore

and Taiwan, play a significant role in Asia today. Many MNCs from Asian NIEs have become major investors in China and Southeast Asia (Yeung, 2001).

2.2.3 Southeast Asia

The development of trade in Southeast Asia[7] relatively lags behind that of Japan and the NIEs. Trade in Southeast Asia began to grow only in the early 1970s. At that time, exports from all Southeast Asian countries were primary commodities especially agricultural products and minerals (Lim, 2004), such that the demand for these products from the rest of the world (ROW) became very important for Southeast Asian countries to achieve a comparably high growth rate and development. For example, in the early 1970s, natural rubber, petroleum, sugar, coconut oil, copra and plywood were exported to the United States with the value of those exports reaching US$2,198 million (Lim, 2004). At the same time, products such as textiles and clothing were also exported to Europe and Japan. From the import side, Southeast Asia was a key importer of products such as electric and non-electric machinery, transport equipment and agricultural commodities such as wheat, cotton and tobacco. The main sources of Southeast Asia's imports are the United States and Japan. Japan accounted for more than 30 percent of Southeast Asian imports (Welch, 1973).

Although exports of agriculture products were still growing in most Southeast Asian countries (especially Indonesia, Malaysia, Thailand, and the Philippines),[8] in the 1980s the principle role of Southeast Asian countries as exporters of primary

[7] It has been defined in Section 2.1.

[8] 70 to 80 percent of Indonesia's exports were primary commodities, and this country became the biggest exporter of petroleum in Southeast Asia. Export of primary commodities by Malaysia, the Philippines and Thailand was 65 percent, 50 percent and 60 percent of their total exports, respectively.

commodities gradually switched towards exporting manufacturing goods. This might have been because subsidiaries of foreign firms, especially from the United States, had started manufacturing electronic components in this region to meet their parent companies' needs in the United States (Lee and Naya, 1988). The percentage of manufactured goods in terms of total exports increased to more than a quarter in Malaysia, Thailand and the Philippines, even though there was a slower growth in the global economy as well as other external disruptions in the early 1980s (ADB, 1985). In addition, Indonesia as the least industrialised country in the region also experienced similar high growth in manufactured exports.

Since the second-half of the 1980s, there has been a significant change in the structure of trade in Southeast Asia. At the time, the major exports of Southeast Asia changed from primary commodities to manufactured products such as machines, transport equipment and miscellaneous manufactured goods (Lim, 2004). In the late 1980s and early 1990s, more than 50 percent of Southeast Asia's exports were manufactured products (Fukuda and Toya, 1995). One of the reasons behind these changes was the increase in demand for manufactured products. The massive appreciation in the Japanese Yen since the Plaza Accord initially increased the demand for manufactured products from the Asian NIEs. And since the NIEs' currencies also appreciated substantially in the late 1980s, the demand for manufactured-oriented products shifted towards the ASEAN countries (Fukuda and Toya, 1995). In addition, the trade growth in manufactured products due to increases in demand led to the rapid economic growth in Southeast Asian countries. Between 1975 and 1997, the average of annual economic growth rate in the ASEAN-5 (i.e., Singapore, Malaysia, Thailand, Indonesia, and the Philippines) was about seven percent compared to global growth rate of three percent. And at the same time,

ASEAN-5's share in world trade increased from three percent to six percent (Hurley, 2003).

Changes in the composition of Southeast Asia's exports were also due to policy changes implemented in many countries of the region. After independence, most countries in the region adopted an inward-oriented trade strategy[9]. High tariff barriers were imposed on foreign goods in an effort to protect the local industries (Welch, 1973). However, in the late 1980s and early 1990s, most countries in the region (especially ASEAN countries) shifted to an export-oriented strategy. The export-oriented manufacturing industry (EOI) policy undertaken by many Southeast Asian countries, particularly Malaysia, Thailand, Indonesia and the Philippines, has led to a favourable economic performance in those countries (Urata, 1994; Lim, 2004).

In 1992, the ASEAN Free Trade Agreement (AFTA) was established at the Fourth ASEAN Summit in Singapore. At the time, ASEAN consisted of six countries, namely, Malaysia, Indonesia, Brunei, Thailand, Singapore, and the Philippines. The goals of AFTA are: (1) to increase comparative advantage as a production base in the world market through elimination of tariff and non-tariff barriers among ASEAN members; (2) to attract more FDI to ASEAN. Under the Common Effective Preferential Tariff (CEPT) scheme, which became effective in January 1993, tariffs for all manufacturing and processed agricultural goods were reduced to 0-5 percent by 2003 (Rana, 2006). At the same time, all non-tariff barriers in ASEAN countries were eliminated. After two years of implementation, the percentage of CEPT goods in intra-ASEAN export rose to 82 percent per annum while the annual export growth

[9]Many Southeast Asian countries implemented an Import-substitution Industrial policy (ISI) in the 1960s and 1970s.

in CEPT goods within ASEAN countries was at 19 percent (Naya and Plummer, 1997).

In 1995, membership of ASEAN was extended to include Vietnam. The goal of ASEAN-10 was ultimately achieved when Laos and Myanmar joined ASEAN in July 1997, followed by Cambodia in 1999. Extending membership to new members was seen as beneficial to ASEAN as a whole. For example, in the long term, new ASEAN members would help improve the region's level of competitiveness. This would provide an opportunity for ASEAN businesses to reduce their production and increase their export market share. Besides, ASEAN's enlargement would also increase the political stability of the Southeast Asian region as well as enhancing its capacity and influence in international affairs (Singh, 1997).

ASEAN also realised that there was a need for its new members to "catch up" with other ASEAN members. In order to reduce the economic gap between the new members and the old ones, many things had to be taken into account. For instance, in 1996, ASEAN leaders launched their initiative on the ASEAN-Mekong Basin Development Cooperation. This initiative was aimed at enhancing the economy and promoting development in the Mekong area by generating resources and providing new members with technical and other forms of cooperation.

2.2.4 China

Since China's adoption of an economic policy of openness to international trade and investment in1978, economic changes have made China the most dynamic economy in the world. For example, in terms of the world's export volume, China was ranked

thirty-second in 1978. In the following decade, however, China became the world's thirteenth largest exporter (Wei, 1995). According to Rumbaugh and Blancher (2004), since the open door policy was implemented, Chinese trade grew faster than the world trade for more than twenty years. Nonetheless, in the 1980s China's trade began to slow down after relaxation of pervasive and complex import and export controls (IMF, 2004). Nevertheless, in the 1990s Chinese trade performance continued to grow due to broader trade reforms such as tariff reductions.

In the 1990s, China started to penetrate into developed countries' markets such as those of the United States and the European Union (EU). Trade between China and these developed countries continued to grow in the 2000s. China has since taken over Japan's position and became the United States' third largest trading partner in 2003, after Canada and Mexico. And in that year, the United States became China's second largest trading partner. In 2005, China accounted for more than 14 percent of the United States' total imports, up from 12 percent in 2003 (Lum and Nanto, 2007). The EU is also an important Chinese trading partner after the United States. In 1993, trade volume between China and the EU reached the amount of US$26.15 billion, and this figure has increased 20 times (i.e. to US$ 479.71 billion) by 2010 (China Customs Statistic, 2013).

The role of China in terms of Asian regional trade has also become increasingly important. Trade with its Asian neighbours (particularly with Japan and the Asian NIEs) has increased rapidly. China has become the largest trading partner of both Japan and Taiwan. At the same time, China has also become the largest export market as well as the largest destination of foreign investment for the Republic of Korea (Lum and Nanto, 2007). In addition, the share of China's imports through a

vertical specialization of production with Asian countries has also increased. This, plus rising imports for domestic consumption, has made China into one of the major export markets for the other Asian countries (Rumbaugh and Blancher, 2004).

In terms of export commodities, at the beginning of the policy reform period (i.e., in the late 1970s)[10], China's exports consisted predominantly of primary products such as oil and agricultural products. After the first two decades of reform, however, China started to shift its exports to labour-intensive products such as textiles and clothing. In the current phase of reform, China has started to export capital-intensive products such as steel, machinery and automobiles. By 1993, labour-intensive and capital intensive products have increased substantially in which total manufacturing goods accounted for about 88 percent of China's total exports. At the same time, China's exports of agricultural products and minerals declined significantly (Song, 1996).

2.3 Theoretical literature on IPNs

It is important to take a closer look at trade theories, given the key role played by trade relationship in the development of the region, as evident from the account provided in the previous section. However, trade theories per se cannot explain the phenomenon of IPNs in East Asia. Therefore, investment theories and the concept of international division of labour are also important, and therefore ought to be discussed, as they are believed to have an influence on the development of IPNs.

[10]In 1978, agricultural products accounted for about 36.1 percent of all Chinese exports (Song, 1996).

2.3.1 Theories of international trade

The importance of international trade to any country's development and economic welfare has been heavily documented in literature on economics since it was introduced by Adam Smith in his book, *The Wealth of Nations*. The rationale underlying this is to generate revenue to pay for imported goods and services which cannot be produced indigenously. In the following sub-section, we will review the theories of international trade starting with traditional ideas of comparative advantage, progressing through the flying geese and variants thereof (i.e., the spiral development model) before considering new economic geography (NEG) explanations and the role of vertical specialisation. The evolution of those theories is actually in line with the development of trade in East Asian region.

2.3.1.1 Traditional comparative advantage theory

As discussed in the previous section, East Asia has undergone a number of changes as far as trade pattern is concerned since World War II. In the 1960s and 1970s, trade in East Asia was dominated by typical North-South inter-industry trade patterns where Japan exported a wide range of final manufactured products to East Asian developing countries, while the latter exported primary commodities and labour-intensive products to the former. This type of trade patterns is explained well by the traditional theory of comparative advantage proposed by David Ricardo, which says that each country is not equally suited to produce all goods and services because every country is not similarly endowed. As such, it makes sense for a particular country to specialise in producing goods and/or services which it can best deliver while leaving the production of other goods and services to other partner-countries.

In other words, trade patterns and production specialisation are determined by relative factor productivities.

Ricardo's theory of comparative advantage has since been extended in the Heckscher-Ohlin model to show how factor proportions can determine a country's comparative advantage. Heckscher-Ohlin in their first theorem emphasised that specialisation and trade in any country are determined by relative factor endowment. In this respect, a country will export products whose production requires the intensive use of the country's relatively abundant and cheap factors, but will import products whose production requires the intensive use of the country's relatively scarce and expensive factors. For example, Indonesia (a labour and resources abundant country) will export agricultural products, but will import high tech products such as cars and computers. In contrast, Japan (a capital abundant country) will export high tech products such as cars, but will import products such as petroleum.

In this theorem, the tastes and income distributions of all countries are assumed to be identical, leading to the equalisation of demand for final products and factors of production in different countries. Nonetheless, the supply factors of production are different from country to country due to the difference in relative factor prices between countries. Therefore, by assuming a comparable level of technology for each country albeit with different factor prices, this would of course lead to differences in the relative price of commodities -hence trade.

Nonetheless, rapid industrial upgrading and favourable economic performance in many East Asian countries in the 1970s and 1980s, as well as the rise of Japan, have

led to the miraculous development in East Asian region. At that time, the NIEs seem to have followed closely the Japanese footsteps, and later ASEAN and China. In this manner, the traditional comparative advantage is insufficient to explain the subsequent development of trade in East Asia. Therefore, the first theory that may enable to explain such developments is the flying geese theory, formulated by Akamatsu (1932).

2.3.1.2 The "flying geese" theory and related theories

Between the 1970s and early 1990s, the development of trade in East Asia appears to be described by the theory of the "flying geese" pattern of industrial development. As stated in Kojima (2000), this theory was first introduced by Akamatsu in 1930s and according to which, developing countries adopt the industries of developed countries and undergo a catch-up process of industrialisation in order to achieve rapid economic growth. Based on this theory, countries are divided into three sub-groups, namely *senshinkoku* (leading countries), *shinkookoku* (advanced follower countries) and *kooshinkoku* (follower countries). There are three stages in the development of imports, production and export in the basic structure of flying geese development pattern. Firstly, developing countries enter the international economy, their primary products are exported, and industrial products for consumption are imported from developed countries[11]. Secondly, developing countries start to produce products that they used to import from developed countries. This initiative leads to a gradual reduction in the import of those products while at the same time the import of machinery to ensure the production of those products increases. Thirdly,

[11]This is because developed countries have a comparative advantage in terms of producing higher quality and cheaper products.

developing countries start to export their products to an increasing number of overseas markets (Akamatsu, 1961).

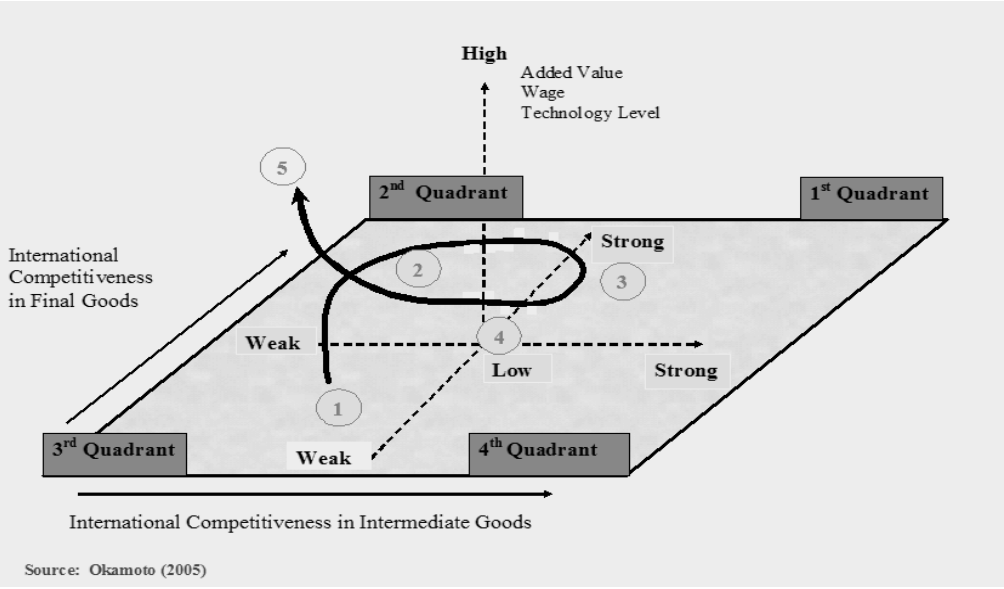
In the case of East Asia, a number of authors (e.g. Kasahara, 2004; Kojima, 2000) claim that the flying geese paradigm of dynamic comparative advantage accurately explains the "catch-up process" of East Asian countries through a regional hierarchy. In this hierarchy, industrial development is transmitted from a lead goose (i.e., Japan) to second-tier countries (i.e., Asian NIEs viz., the Republic of Korea, Taiwan, Singapore and Hong Kong). After these two groups, development is then transmitted to the main ASEAN countries (i.e., Malaysia, Indonesia, the Philippines, and Thailand) and finally to China and the least developed countries (such as Vietnam). This paradigm occurs when countries at the top of the hierarchy implement internal restructuring due to increasing labour costs.

The theory of "flying geese" is closely related to the "product life cycle" theory introduced by Raymond Vernon (1966). The "product life cycle" theory argues that many manufactured products go through four product cycles, namely: introduction, growth, maturity, and decline. Nonetheless, this theory has been unable to explain the situation in East Asia. This is because the "product life cycle" tends to observe the phenomena of development from the perspective of developed countries (Fujita, 2007) where trade in manufacturing is largely based on a horizontal division of labour. On the other hand, the flying geese model is more suited to East Asia because this theory observes the same phenomena from the perspective of developing countries (Fujita, 2007) where trade in manufacturing is based to a large extent on a vertical division of labour.

2.3.1.3 The "spiral pattern of development" model

The key idea in the "flying geese" model (i.e., vertical division of labour) was extended in the "spiral pattern of development" model introduced by Okamoto (2005). This model suggests that the process of industrial development in any country moves through a circular and clockwise path around the diagram of International Competitiveness Index[12] where they become more and more competitive over time due to technological improvement. However, if factors such as changes in wages, changes in the levels of technology, and changes in the level of value added (i.e., from a three-dimensional point of view) are taken into account, the development of industries seems to move up spirally along a vertical axis (see Figure 2.1). This model has been developed by taking into account the IPNs that is increasingly vibrant in East Asia. Therefore, industries'/countries' international competitiveness in both final products and intermediate products will be used to examine the development of those industries.

Figure 2.1: The Spiral Pattern of Development Model (Three-dimensional)



[12]International Competitiveness Index (ICI) = (Export - Import) / (Export + Import).

Based on this “Spiral Pattern of Development” model, countries will go through five stages in the path of industrial development alongside improvement in their industrial technology. In the first stage, countries’ demand for both final products and intermediate products exceeds domestic productions as these countries are not competitive in producing either intermediate products or final products. At this stage, both products have to be imported from outside. In the second stage, a country gradually develops strength in the assembly production by using the advantages of cheap labour as well as foreign technology. At this stage, the country imports more intermediate products to be assembled as final products. These final products would then be exported to other countries. Countries/industries in turn enter the third stage when they have adequately improved their level of technology. At this stage, industries/countries start to produce both intermediate products and final products. When industries/countries reach a certain level of maturity (i.e., in the fourth stage), they would lose their comparative advantage in assembling activity as the wage of labour in that industry/country starts to increase. At this stage, the country/industry focuses more on producing intermediate products which are capital-intensive. In the final stage, industries/countries lose their comparative advantage. They compete in both the domestic and world market and specialising in differentiated products that are high in quality and use high technologies.

2.3.1.4 New economic geography (NEG) theory and fragmentation theory

Since the early 1990s, the patterns of trade in East Asia have become more complicated compared to previous decades, with intra-East Asia trade increasing dramatically due to the rapid growth of trade in machinery P&C (Kimura, 2006). This phenomenon reflects the existence of IPNs between a numbers of countries in

the East Asian region. The formation of IPNs is well explained by the new economic geography theory, introduced by Krugman (1991)[13] and the fragmentation theory introduced by Jones and Kierzkowski (1990).

The NEG theory tries to explain the emergence of agglomerations and dispersion of economies in geographical space which relies on increasing returns to scale and transportation costs. In short, this theory analyses the balance between agglomerations and dispersion forces that constitutes the patterns of economic activities in various locations. This theory is a slightly more sophisticated version of the flying geese theory and described by Krugman (1991) by means of a core-periphery model. Based on this model, agglomeration forces emerge when transport costs are low and at this time countries divided into two groups, i.e., core (industrialised developed countries) and periphery (non-industrialised developing countries) and labour freely moving between regions. In addition, this theory also emphasizes the importance of linkages between firms and consumers as well as between firms and suppliers (Kasahara, 2004).

Krugman's original model (1991) has since been extended by Krugman and Venables (1995). In this extended model they seemed to envisage that agglomeration forces, in turn, generate dispersion forces due to congestion in labour and property markets. In this respect, there is no labour mobility but that manufacturing production has moved from the core countries to the peripheral countries. Initial reduction in transport costs led to countries dividing themselves into core-periphery patterns. Nonetheless, when the reduction in transport costs continues to the point that firms in developed countries realise that the advantage of low wage in the

[13]These two theories deal with the production process and division of labour, while the flying geese theory deals with industrial division labour.

periphery countries can offset the disadvantage of operating in home countries that are far from their home markets, manufacturing in the core countries will shift more and more to the periphery countries.

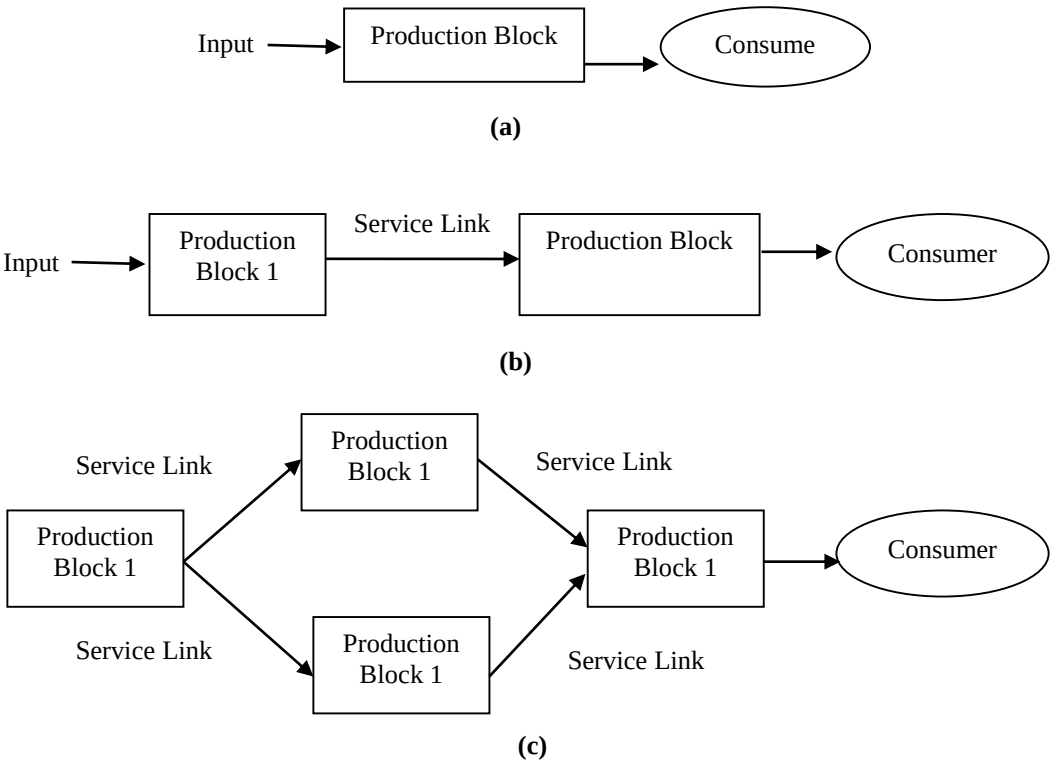
It is well documented that beside the NEG model, the fragmentation model (which is specific to the production process) is also useful and at the same time become as a complement to the NEG model in explaining IPNs in East Asia. This is because when transport costs are low, production can fragment and that while fragmented production block tend to concentrate in one region within a country, they eventually disperse throughout the neighbouring countries (Hiratsuka, 2011). Moreover, Ando and Kimura (2009) and Kimura (2006, 2008) for examples, found that agglomeration and fragmentation is observed together in the East Asia's IPNs.

The theory of fragmentation has been developed by Jones and Kierzkowski (1990) by extending the theory of comparative advantage. Using two key concepts, i.e., production blocks and service link[14], Jones and Kierzkowski (1990) provided a general framework for analysing fragmentation; this framework is illustrated in Figure 2.2. Panel (a) in that figure depicts a traditional production process. In such a traditional production process, production is integrated, whereby all stages of production take place in a single production block, all of which are performed within the same country. In this integrated production process, the roles of service links are to connect activities within the production block as well as to connect production and the market.

[14]Service links are set of activities such as transportation, telecommunications, coordination, administration and financial services that ensure each production block interacts in a timely and cost-effective way.

By assuming that technology within the production block is subject to increasing returns to scale and that the marginal cost of operation is constant, Jones and Kierzkowski (1990) argued that specialisation of the productive task and division of labour may increase as production expands. This situation could in turn lead to the existence of fragmentation. In panels (b) and (c) of Figure 2.2, Jones and Kierzkowski (1990) show a simple pattern and a complex pattern of the fragmented production process, respectively. In both patterns, the output produced by one production block will be used as input by the next production block. Besides, as production stages are actively separated, service links become more crucial and complex.

Figure 2.2: The Production Process



Source: Jones and Kierzkowski (1990)

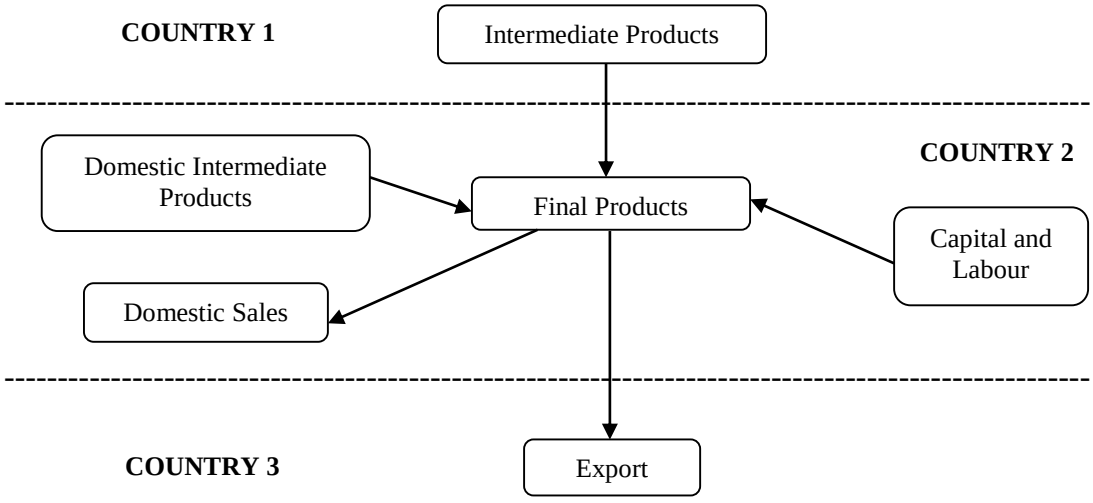
Theoretical studies on fragmentation have grown since it was first proposed by Jones and Kierzkowski (1990). Many have argued, e.g. Jones and Kierzkowski (2000 and

2001), Deardroff (2001) and Graziani (2001), that differences in factor intensity across the different processes within the firm, as well as differences in factor endowments and productivities at the international level between developed and developing countries are the main factors responsible for the international fragmentation in the production process. As a result, developing countries that have low-wages and are labour-abundant will specialise in the labour-intensive segments of production, while developed countries with capital-rich and high wages will specialise in the capital-intensive production segments.

In addition, others have also emphasised that reduction in global trade barriers, transport costs and various coordination costs is also an important factor for ensuring that the fragmentation of production processes is economically viable. For example, Yi (2003) claims that lower tariffs are crucial for stimulating vertical specialisation among countries, while Harris (2001) argued that the coordination costs among suppliers and customer firms in the manufacturing industry have been reduced by the rapid improvement and extension in communication networks such as the Internet. At the same time, Arndt (2001) argued that international fragmentation can enhance countries' welfare under free trade conditions. Therefore, policy reforms in both home and host countries that reduce the service link costs and network set-up costs are also important for enabling production fragmentation to occur. This is because the fall in trade barriers such as tariffs, transportation costs and telecommunication costs as well as technological advances and greater knowledge of other countries' legal system have reduced the influence of distance and consequently encouraged fragmentation across national borders.

Hummels et al. (2001) introduce the concept of vertical specialisation as sequential linkages between countries in producing goods. In this respect, a country uses imported intermediate products to produce products or products-in-process and then exports them to other countries (see Figure 2.3). Hummels et al. (2001) claim that there are four conditions that allow vertical specialisation to occur: (1) the production of a good requires two or more sequential stages; (2) two or more countries provide value added in the process of producing the good; (3) in the process of producing the product, imported input must be used at least by one country; (4) some of the finished products must be exported to other countries.

Figure 2.3: The Concept of Vertical Specialisation



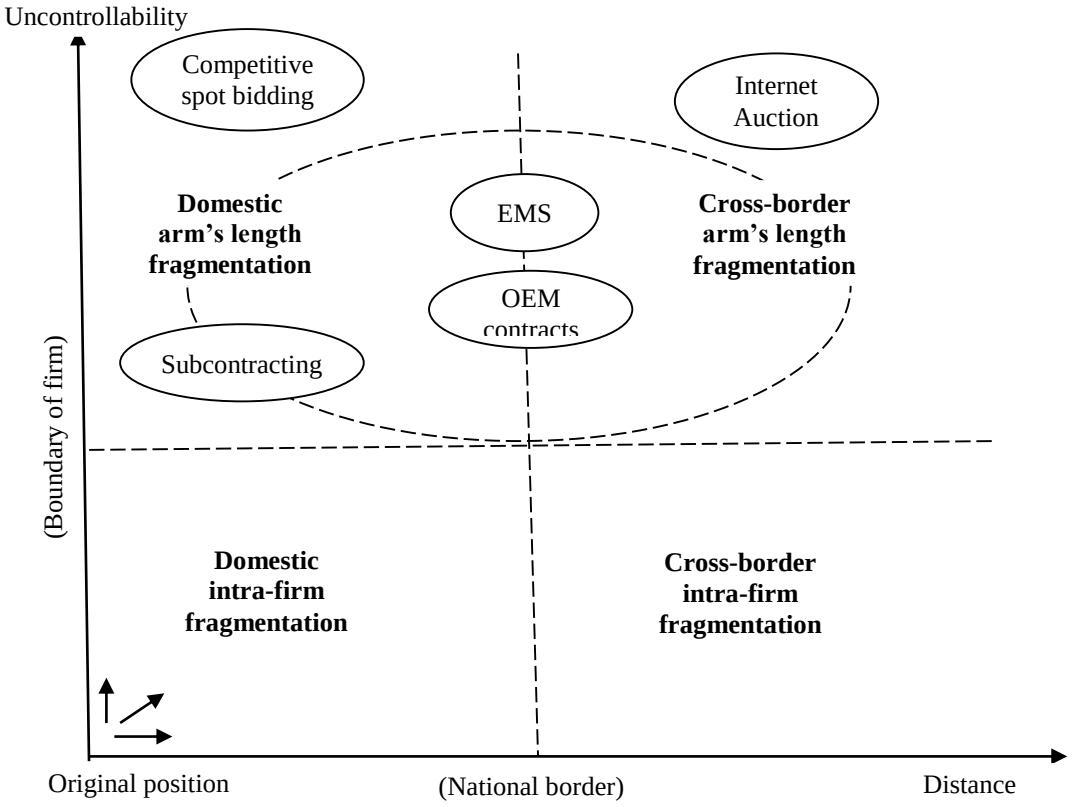
Source: Hummels et al. (2001)

According to Kimura and Ando (2005), features of the IPNs in East Asia are somewhat unique as it involves a combination of both intra-firm and arm's length (inter-firm) transactions[15]. To capture this sophisticated nature of IPNs, Kimura and Ando (2005) have mapped out a two-dimensional model of fragmentation (see Figure 2.4) which proposed the concept of fragmentation and agglomeration. The

[15]This type of fragmentation is more sophisticated than the fragmentation between US and Mexico, and between Germany and Central/Eastern Europe.

horizontal axis represents the geographical distance, while the vertical axis represents the disintegration or uncontrollability of corporate activity.

Figure 2.4: Two-dimensional Fragmentation Model for East Asia



Note:
ESM =electronics manufacturing service, OEM=original equipment manufacturing, and Internet auction=auction of customised P&C through internet. The horizontal and vertical dotted lines represent boundary of firm and national border respectively, while the dotted circle represents agglomeration.

Source: Kimura and Ando (2005)

A dotted line has been drawn in the middle of the horizontal axis to represent the national border. This boundary distinguishes between domestic fragmentation and cross-border fragmentation. In this respect, domestic fragmentation refers to the firms' decision to fragmented production block within the national border whereby the distance is short, while cross-border fragmentation refers to the firms' decision to fragmented production block beyond national border. Again, a dotted line has also

been drawn in the middle of the vertical axis to represent the firm's boundary. This boundary distinguishes intra-firm transactions from inter-firm. When the fragmented production block located beyond the boundary of firm, the relationship becomes arm's length (i.e., inter-firm or outsourcing).

There still exist different degrees of uncontrollability among domestic arm's length transactions. For example, competitive bidding in the spot market have the weaker controllability compared to that of subcontracting system. In the case of cross-border arm's length fragmentation transactions such as internet auction (procurement of customised P&C) require frequent spec changes and exact delivery timing, and thus upstream and downstream firms must locate nearby. In this situation, we can see the connection between fragmentation and agglomeration through inter-firm fragmentation inside agglomeration channel. For example, agglomeration of computer P&C manufactures in Dongguan, China where more than 30, 000 Taiwanese companies are networking in a just-in-time manner. Shah Alam in Malaysia for electric and electronics machinery and Guangdong in China for copy machine are also the examples (Kimura and Ando, 2005).

Service link costs and production costs are two important factors that need to be considered by firms when it comes to deciding whether (or not) to fragment. In the case of traditional fragmentation (i.e., in terms of distance), service link costs increase when the distance between the original position and the location of the fragmented production block increases. However, location advantages (such as wage level, factor availability, infrastructure and technology transfer) may lower the total production costs. Meanwhile, in the case of fragmentation along the uncontrollability (or disintegration) axis, transaction costs increase when firms lose their controlling

grips over the fragmented production block[16]. These costs, however, can be offset when the firms' business partners have better technology and managerial ability.

2.3.2 Theories related to FDI

Theories of FDI have been grouped according to either a microeconomic or macroeconomic perspective. From a micro perspective, FDI theories try to provide answers as to why MNCs would prefer to open subsidiaries abroad rather than exporting or licensing their products, how MNCs choose their investment locations, and why they invest where they do. On the other hand, from a macro perspective, FDI theories try to analyse country characteristics that explain FDI flows within and across countries. In the following sub-section, we discuss some FDI theories, namely: market imperfection theory, internalization theory, and Dunning's eclectic paradigm for international production.

2.3.2.1 Market imperfection theory

The market imperfection theory was developed by Hymer (1976) which was aimed at explaining the behaviour of firms in imperfect competitive environments. Based on this theory, firms tend to invest abroad because of their unique advantages such as technological knowledge and economies of scale. Obviously, with such advantages the firms would be able to exercise some form of monopoly in the market and in turn allow them to compete abroad with local firms who already have location specific advantages.

[16]Those costs are due to incomplete information and a lack of credibility.

Technological knowledge comprises production technologies, managerial skills, knowledge of product, and industrial organization. Even though the MNCs could possibly exploit its already developed superior knowledge through licensing to foreign markets, many types of knowledge cannot be directly sold. This is because it is impossible to package technological knowledge in a license, as is the case with managerial expertise, industrial organization, knowledge of markets, and the like. Even when knowledge can be embodied in a license, the local producer may be unwilling to pay its full value because of uncertainties about its utilization. For these reasons, the MNC has realised that it can obtain a higher return by producing directly through a subsidiary than by selling the license.

Economies of scale take place through either horizontal or vertical FDI. An increase in production through horizontal FDI allows for a reduction in unit cost of services such as financing, marketing and technological research. Since each overseas plant produces a homogenous product in its entirety, horizontal FDI may also have the advantage of allowing a firm to even out the effects of business cycles in various markets by rearranging sales destinations across countries. Meanwhile, through vertical FDI where each affiliate firm produces parts and components of the final product for which local production costs are lower, MNCs may gain benefits from local advantages in production costs while achieving maximum economies of scale in the production of single components. Such international integration of production would be much more difficult through trade because it needs the close coordination of different producers and production stages.

2.3.2.2 The internalization theory

The theory of internalization, which was developed by Buckley and Casson (1976), is regarded as a modern theory of MNCs (Alan, 1999). In this respect, this internalization theory demonstrates that MNCs are organizing their internal activities so as to develop specific advantages, which are then to be exploited. This theory was then expanded by Hennart (1982) through developing models between the two types of integration, i.e. vertical and horizontal FDI. Due to the existence of market imperfections, the theory articulates that a firm is threatened by inefficient market conditions for a product or services. Inefficient market conditions include high and unstable transaction costs, insecure supply of inputs, inadequate protection of intellectual properties, difficulty in execution and enforcement of contracts, etc.

Buckley and Casson (1976) suggest that firms can overcome these conditions by making use of their monopolistic advantages to internalise their transnational business activities within the firm. This action, in turn, would lead to a reduction in transaction and coordinating costs and/or risks associated with using external agents who can link firm to customers.

The theory can explain why a firm will choose international production or independent intra-firm trade over inter-firm trade[17]. Thus, it can explain one important aspect of the rationale for FDI, namely, the existence of inefficient market conditions. Nonetheless, it ignores other important factors that shape a firm's FDI decision, such as locational or ownership advantages.

[17] Inter-firm trade includes trade under contractual arrangements, licensing, franchising, contract manufacturing, etc.

2.3.2.3 Dunning's eclectic paradigm for international production

Dunning (1980, 1988) considered the internalisation theory to be very important and used it in his eclectic theory. But he argues that the internalisation theory explains only part of the FDI flows. He draws partly on macroeconomic theory and trade as well as microeconomic theory and firm behaviour. The eclectic theory attempts to explain the motives and determinants for firms from one country to undertake international production through FDI in another country instead of exporting or entering into a licensing arrangement with a local firm.

The theory argues that the participation of firms from one country in the value-adding activities in another country is determined by: firstly, the extent and characteristics of the competitive or ownership (0) specific advantages of investing (or potentially investing) firms, relative to those headquartered in the recipient or host country; secondly, the locational (L) attractions of the recipient country, relative to those of other countries including the investing country, especially with respect to activities necessary to optimize the economic rent on the O-specific advantages of the investing firms; finally, the extent to which it is in the best interests of a foreign firm to internalize (I) the market for its O-specific tangible and intangible assets rather than choose another organizational mode, e.g. licensing, management contract, franchising, etc., by which these assets, or the rights to their use, are transferred; or indeed, by which their value may be protected or augmented, and hence referred to as the OLI paradigm.

Based on this theory, O-specific advantages refer to intangible assets that are exclusively possessed by the firm and may be transferred within MNCs at lower

costs, leading to higher incomes or reduced costs. O-specific advantages include factors such as firm size, economies of scale, market power, technological edge, and the availability of inexpensive finance. When the first condition is fulfilled, the L-specific advantages determine who will become the host country for MNCs' activities. In this respect, firms relocate their business activity in a host country because it is more profitable than any other domestic location in their home country, as they can exploit resources available in the host country. The advantages of quantitative and qualitative factors of production, resource availability, lower costs of transportation, telecommunications, large market size, common government policies, distance from the home country, cultural relations, etc., are L-specific advantages. The importance of superior production processes, cheap labour and nearness to customers is that these are factors that make production by MNCs preferable in host countries.

When the first two conditions are fulfilled, it will be profitable for a firm to use these advantages in collaboration with some of the factors outside the firm's country of origin (Dunning, 1973, 1980, 1988). The I-specific advantages include firms' abilities to carry their patents, trademarks, raw materials, and marketing techniques to all their establishments abroad without incurring additional costs. In this respect, firms benefit more from controlling their foreign business activity rather than from hiring an independent local company to provide the service. This theory shows that OLI parameters differ from firm to firm and reflect the economic, political and social conditions of the host countries.

The OLI paradigm suggests that when firms invest abroad they tend to replace exports of the home country and imports of the host country. For example, if a firm

invests abroad to exploit cheap labour, it is exploiting a location advantage and tends to replace home country exports with FDI. Similarly, a multinational is exploiting its ownership advantage when it gains access to the host market through ownership of subsidiaries. Sales from subsidiaries in the host economy tend to replace exports from the parent company in the home economy. Many large MNCs also invest in subsidiaries in the host economy that produce intermediate products. These multinationals exploit advantages accrued due to internalisation, and tend to replace exports of inputs from the home country.

2.3.3 The concept of international division of labour

The concept of international division of labour (IDL) is essentially generated from two trade theories that have been discussed earlier, namely, the theory of Comparative Advantage and the theorem of Factor Proportion. In this respect, the reason behind the occurrence of trade between countries as well as its mutual benefits can be deduced from the theory of comparative advantage, while the difference in countries' factor of production (labour) (which attributes the comparative advantage) can be deduced from the theorem of factor proportion (Mitschke, 2008).

The concept of IDL has gone through several phases of change. The old IDL existed between 1850 and 1950. During that period, manufacturing industry was heavily concentrated in Western Europe, USA, and later Japan (i.e. core countries). These countries were engaged in agricultural, mineral and basic commodity production, which were then traded with nearby countries. In this respect, the IDL was predicated on exchange between core countries and extraction of unprocessed agricultural

commodities and mineral wealth from their colonised states (Walton, 1985). In that period, much of international trade was channelled by the colonial empires, which added political dominance to economic dominance. In contrast, the colonised states were for the most part only incorporated into the capitalist world economy as raw material suppliers (Frobel et. al, 1978).

In the mid-1960s, however, the pattern of the old IDL started to change. At the time, the Bretton Woods system of fixed exchange rates collapsed and rates of profit fell particularly in the United States, which also went into a balance of payments deficit and financed it by exporting dollars and creating inflation. In facing these problems, many manufacturing companies went multinational (i.e. internationalizing production to lower the costs and open up new markets) to restore profitability. This situation, in turn, led to the occurrence of the new IDL as well as the emergence of NIEs such as South Korea, Taiwan, Hong Kong, and Singapore (Dicken, 1998).

The new IDL seems adapted to the borderless economy where natural resources (such as rubber or copper) can be extracted in one part of the world and then processed in another part to become consumer goods (such as sports shoes in the case of rubber, or computers in the case of copper) that are then distributed in developed economies' markets where they were initially designed (Coffey, 1996). Moreover, global production chains are designed specifically for the maximal exploitation of labour. In these production chains, particular countries are specialised in different branches of production, irrespective of whether this be in certain products or in selected parts of the production process.

In addition, during occurrence of new IDL, the advent of new forms of communication and transportation technology has made it possible for MNCs to relocate their factories to developing countries where the cost of labour would be substantially reduced. As a result, developing countries have increasingly become the location site of manufacturing industries for competitive production in the world market. In addition, through the new IDL, the dissemination of markets and production processes worldwide has led to an increased differentiation in economic activity.

2.4 Empirical literature on IPNs in East Asia

The theories which have been discussed earlier have assisted us to observe the nature, characteristic and properties of IPNs. To prove the theory, we need carry out empirical studies. Up till now, several studies have investigated the characteristics, properties and nature of that phenomenon by measuring the degree of vertical specialisation that exists between countries. In addition, other studies have also investigated the factors that stimulate IPNs as well as the impact of this phenomenon.

2.4.1 The degree and nature of vertical specialisation in East Asia

It is important to obtain a good measure of vertical specialisation so as to validate fragmentation theory as well as to understand trade linkages between countries in recent years. However, the degree of vertical specialisation is difficult to measure accurately. Until now, there is no single piece of research claiming comprehensive data or an ideal technique for gauging vertical specialisation directly. According to Formentini and Iapadre (2008), direct measurement of vertical specialisation requires

firm-level survey data that document all stages in the production process for each product. They, however, argued that given obstacles such as the high cost of running a suitable survey let alone its complexity has led to only a few countries having the requisite kind of datasets. At the same time, there is also the problem with the reliability of the data as firms may refuse to cooperate in providing certain detailed information on sensitive issues such as shifting production abroad. As an alternative, in the empirical literature, researchers such as Hummel (1998, 2001), Athukorala and Yamashita (2006), Yi (2003) have used trade in intermediate goods as a proxy to the international production chain activity. But even here different researchers have used different sources of data and techniques to quantify intermediate goods that cross national borders, including Processing Trade Statistics, Input-Output Tables, and International Trade Statistics.

Processing Trade Statistics and Customs Statistics have been used interchangeably in the literature. It can be broken down into two categories, namely, Outward Processing Trade and Inward Processing Trade. Outward Processing Trade refers to goods that are re-imported back to the home country after being exported abroad for processing. Whereas, inward processing Trade refers to goods that are re-exported to the home country after being imported for processing. Examples of such data are the China Customs Trade Statistics, US Offshore Assembly Programme, and the European Union Processing Trade Datasets. The advantage of using this type of data is that by definition, the goods traded for processing are intermediate and may cross national borders more than once (Formentini and Iapadre, 2008). The drawback of using this data is that it does not capture other items unless they are exported abroad for processing and then re-imported or are imported for processing and then re-exported (Amador and Cobral, 2008).

Gaulier et al. (2005), and Dean et al. (2009) are among researchers that used Processing Trade Statistics to quantify vertical specialisation for the case of East Asia. Using China's custom statistics on processing trade, Gaulier et al. (2005) argued that IPNs between China and other Asian countries have developed rapidly through international processing activities. In addition, China has been used as an assembly base with the finished products being exported to the United States and Europe. Dean et al. (2009) used China's customs data between 1995 and 2007 (as obtained from the United States International Trade Commission) to examine the pattern of trade between China and its two largest trading partners, namely, Japan and the United States. In this study, they found that a two-way trade and vertical specialisation extensively occur between China and her largest trading partners, particularly when it comes to trade in communication devices and computer.

Meanwhile, Swenson (2005) is among researchers who use Processing Trade Statistics to quantify vertical specialisation in the case of non-East Asian countries. She examined the effect of costs on the US outsourcing assembly activities between 1980 and 2000. In her study, she argued that these activities grew in the period under study when the country's costs fall or its competitors' costs rise. In this respect, she envisaged that tariff reductions offered by US trade preference programme such as the US-Caribbean Basin Trade Partnership Act would stimulate the US outsourcing assembly activities.

Input-output tables refer to the transaction matrices that document the flows between sales and purchases of final and intermediate product outputs or industry outputs (Yamano and Ahmad, 2006). The matrix columns represent users or consumers whereas the matrix rows represent suppliers or producers. As explained in Wixted et

al. (2006), this transaction matrix consists of five sections. The first section is domestic intermediate matrix. The second section is the adjustment required to derive total intermediate inputs used in production at the purchasers' price. The third section is the value added constituent (at basic prices) such as wages and net taxes. The fourth section is the supply of intermediate goods required by final consumption (households and general government) as well as investment and exports. The final section is imported goods for final use. In the literature, there are two types of approaches that have been used to measure vertical specialisation using input-output tables (Hijzen, 2005; Amador and Cobral, 2009). The first approach considers the foreign content of domestic production. In this approach, the share of imported intermediate input in production has been taken as a proxy for measuring the degree of vertical specialisation. Most studies that utilised this approach have been carried out outside the East Asian region. Examples of such studies include Feenstra and Hanson (1996), Campa and Goldberg (1997), and Hijzen (2005).

Using disaggregated imported data collected at the border by the United States Census for the years 1972 to 1994, Feenstra and Hanson (1996) found that IPNs increased steadily between that period and have affected rate of unemployment and relative earning of unskilled labour in the United States. In this respect, IPNs affect the former positively, while the later negatively. Meanwhile, Campa and Goldberg (1997) used data of imported intermediate input between the early 1970s and the mid-1990s to construct measures for external orientation for American, Canadian, British and Japanese manufacturing industries. In this study, they found external orientation in the United States, Canada, and the United Kingdom increased dramatically for the years under study. In addition, by using input-output table of

United Kingdom for the period 1974-1995, Hijzen (2005) argued that the rise of IPNs affect employment opportunities in the UK particularly for unskilled workers.

The second approach considers instead the direct and indirect foreign content of exports. In this respect, the imported intermediate inputs used to produce goods for domestic use will not be considered. This approach has been used by Chen and Chang (2006), Wang et al. (2009), and Amador and Cobral (2009) in examining vertical specialisation in East Asia. Chen and Chang (2006) argued that a large portion of trade for Taiwan and the Republic of Korea has moved towards a pattern of vertical specialisation. Most notable is the manufacturing sector whose vertical specialisation share of exports has been dramatically increased and has accounted for more than 90 percent of the total vertical specialisation shares of manufactured exports. They also pointed out that for Taiwan, almost 57 percent of the growth in exports is contributed by growth in the vertical specialisation-based trade, while for the Republic of Korea the figure is as high as 64 percent.

Wang et al. (2009), who extended the indices developed by Hummels et al. (2001) to quantify the degree of vertical specialisation along the East Asian production networks between 1990 and 2000, pointed out that East Asian developing economies (i.e. China and ASEAN-4) have become more deeply integrated into the East Asia production networks. Additionally, they also found that the electronics industry has the most integrated IPNs, while automobile production still mainly involved Japan and the Republic of Korea in the year 2000, with developing Asia only starting to show up in the chain. Meanwhile, by using a measure of vertical specialisation-based trade that combines information from I-O matrices and international trade data, Amador and Cobral (2009) found a significant increase in vertical specialisation

activities in high-tech products in East Asia over the last two decades. Among studies conducted in non-East Asian region that used this approach are Hummels et al. (1998, 2001) and Yi (2003).

Among studies conducted in non-East Asian region that using this approach are Hummels et al. (1998, 2001) and Yi (2003). Hummels et al. (1998, 2001) have developed indices to quantify the degree of vertical specialisation and they concluded that the portion of trade that is vertical specialisation-based is increasing. Specifically, Hummels et al. (2001) claim that vertical specialisation contributes up to 21 percent of the exports of 10 Organization for Economic Co-operation and Development (OECD) and four emerging market countries in 1990 and having grown around 30 percent between 1970 and 1990. Meanwhile, Yi (2003) argued that vertical specialisation grew due to a reduction in the tariff rates.

Input-output tables can be considered as a suitable source for the following reasons. Firstly, analysis across industries and time can be done using this type of data (Hijzen, 2005). Secondly, the value of imported intermediate from the input-output tables is more reliable because it is calculated on the basis of the use of the goods and not their characteristics. Finally, it is easier to identify the characteristic of the production chain using input-output tables because the tables in principle provide information over any required product breakdown. Nevertheless, this type of data still has several limitations as it is difficult to make accurate cross-country and time-series analysis. This is due to several problems such as the following: different countries using different methods when compiling the tables, input-output tables do not update every year, unavailability of a very detailed product breakdown that prevents someone from properly tracking the production chain.

The UN Comtrade officially provides International Trade Statistics with a wide selection of commodity classification, namely, the Standard International Trade Classification (SITC), Harmonised System (HS), and most recently, the Broad Economic Categories (BEC). Even under the SITC, there are several options such as SITC Revision 1, SITC Revision 2, SITC Revision 3, and SITC Revision 4. Similarly, under HS, there are several options such as HS92, HS96, HS2002, and HS2007[18]. Researchers who use trade statistics to measure international production chain will compare the value of trade in P&C, with the value of trade in final goods. An early user of International Trade Statistics in his study of IPNs in the non-East Asian region is Yeats (1998). In his study, Yeats (1998) found that in 1995 trade in machinery and transport equipment components accounts for about 30 percent of total OECD exports of SITC 7 (machinery and transport equipment), and this figure has tended to increase over time. Meanwhile, an early study of IPNs conducted in the East Asian region using International Trade Statistics was initiated by Ng and Yeat (1999). Ng and Yeats (1999) argued that the extent of IPNs in the East Asian region is quite considerable, with low-wage East Asian countries focusing on assembly operations while high-wage East Asian countries focus on the production of P&C.

The study of IPNs in East Asian countries using this type of data was later continued by other researchers such as Athukorala and Yamashita (2006), Ando and Kimura (2005), Kimura et al. (2007), and Kimura and Obashi (2010, 2011). According to Athukorala and Yamashita (2006), trade in P&C in the East Asian region grew dramatically and, given this vertical specialisation-based trade, the degree of dependence among countries in the region is now larger than in both NAFTA and the EU. Meanwhile, Ando and Kimura (2005) as well as Kimura et al. (2007) argued that

[18]Later versions are only available for more recent years.

transactions in East Asian international production involve both intra-firm and arm's length. Using the gravity model, Kimura et al. (2007) also argued that elements in the fragmentation theory such as differences in service link costs and location advantages accurately explain the nature of vertical specialisation in East Asia. Furthermore, service link costs related to the fragmentation of production in East Asia are substantially lower in East Asia compared to Europe. Kimura and Obashi (2010) claim that the intra-regional trade of machinery P&C in East Asia has expanded and is considerably higher than inter-regional trade. Kimura and Obashi (2011) also claim that participation of East Asian countries in the IPNs varies across countries. Based on the ratio of machinery trade in terms of total manufacturing trade, they conclude that the participation of Japan, Republic of Korea, Singapore, Malaysia and the Philippines in the IPNs is relatively high, while the participation of Thailand and China remains more modest and that of both Indonesia and Vietnam, is still low and yet to achieve a full scale.

2.4.2 Determinants and implication of IPNs

The studies of factors that encourage the development of IPNs and its implications have been conducted by several researchers. Many argued that the role of factors such as income, distance, tariffs, market size, language, income gap, government policy and infrastructures is important in influencing vertical specialisation. Most of these researches using the gravity model approach and provide a basic description of this approach by way of introduction.

Using the gravity approach, Athukorala and Yamashita (2006) investigate factors that contribute to the development of fragmentation trade between countries[19]. In their study, they include variables such as GDP and GDP per capita (to capture market size), absolute difference in GDP per capita (to capture technology differences between countries), relative labour costs, distance (to capture transport costs), common border (to capture possible additional advantages of proximity not captured by distance), language (to determine whether the use of a common language can facilitate trade), intra- and extra-regional dummies (to capture the effect of trade agreements such as AFTA, EU, NAFTA, MERCOSUR[20], ANDEAN[21], and CER), dummies of Singapore and Ireland (to capture the role played by these two countries as outsourcing centres), and intra- and extra-regional dummies of East Asia (to capture the role of East Asia as a centre of vertical trade). Findings from this study suggested that in general, GDP, GDP per capita, absolute per capita GDP, distance, labour costs, language, and Singapore are important factors that influence machinery trade in both P&C as well as final products in several regions. On the other hand, the study also provides evidence that FTAs in general do not promote vertical specialisation.

Kimura et al. (2007) investigate the determinants of vertical specialisation in East Asia, Europe and other countries, making use of bilateral machinery trade data for 56 countries from 1987, 1995 and 2003. By using the gravity model, both trade in P&C and trade in final goods are regressed on GDP, difference of GDP per capita, distance, language, and dummies of East Asia and Europe. Findings of this study

[19]Countries involved in their study are Indonesia, the Philippines, Malaysia, Singapore, Thailand, Japan, Republic of Korea, China, Hong Kong, Australia, New Zealand, Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Greece, Portugal, Spain, Sweden, the United Kingdom, the United States, Canada, Mexico, Argentina, Brazil, Paraguay, Uruguay, Bolivia, Colombia, Ecuador and Venezuela.

[20] Its full members are Argentina, Brazil, Paraguay, Uruguay and Venezuela.

[21] Its full members are Bolivia, Columbia, Ecuador and Peru.

indicate that: (1) trade values have a positive correlation with market size; (2) geographical distance affects trade negatively while coefficients for distance are smaller in the case of East Asia compared to Europe. The small coefficients for distance suggested low levels of service-link costs in this region which would promote fragmentation trade in East Asia; (3) in the case of East Asia, the income gap affects trade in P&C positively, while in the case of Europe the income gap affects trade in P&C negatively. In conclusion, by comparing the pattern of international trade in machinery P&C between East Asia and Europe, this study found that the theory of fragmentation is perfectly suited for explaining the mechanics of East Asia's IPNs.

Nodas (2003) estimated the vertical specialisation using index proposed by Hummels et al. (2001) and regressed it on variables related to geography, infrastructure quality, and policy for textile, automobile and electronic industries. This study has utilised a panel data of 52 countries using GTAP database for 1997 and 2001 and the industries included in the analyses were electronics, automobiles and clothing. In general, she found that geography indicators (such as island and landlocked), the quality of infrastructure (such as effectiveness of ports and road density, telecommunication development, telephone density), policy (such as tariff protection and control of corruption), and market size are important determinants of vertical specialisation. In addition, Nordas (2003) also found that per capita income had a negative effect on vertical specialisation in the textile industry but has a positive impact on vertical specialisation in the automobile and electronic industries.

Leitao et al. (2009) examined the determinants of vertical intra-industry trade in auto P&C between Portugal and its partners (i.e., the European Union's 27-member

countries, Brazil, Russia, India and China) between 1995 and 2006 using gravity analysis. In this study, they found that differences in income per capita as well as differences in physical capital endowments (proxied by absolute difference in electric power consumption) and common border affect the vertical intra-industry trade positively, while transport costs (proxy by geographical and nautical distance) and trade imbalance affect the vertical intra-industry trade negatively.

Using dataset for the period 1990-2007, Pomfret and Sourdin (2009) examined whether ASEAN's measures to reduce trade costs achieved their goal. The results suggested that East Asian trade costs have fallen over the period under study with ASEAN countries reducing trade costs by less than the global average in the early 1990s but then by more than the average between mid-1990s and 2003. They also argued that the rapid increase in the number of trade agreements and the falling trade costs in ASEAN have led to the emergence of regional supply chain.

Li (2009) examined the effect of free trade agreements (FTAs) on vertical specialisation-based trade in nine East Asian countries plus the United States using the gravity model. The results from this study suggested that FTAs have a positive effect on vertical specialisation trade as well as promoting deeper integration between countries. This result is in line with Gonzalez (2012) who examined the impact of FTAs on vertical specialisation using an augmented gravity model. By using matched trade data and input-output table for selected 39 countries between 1995 and 2008, Gonzalez (2012) found that FTAs increased the imports of intermediate goods by around 25 percent. However, when a more targeted measure of bilateral value chain activity is taken into account to capture the value of intermediate imports used to service exports to the same country of origin, the effect

of FTAs increased to 65 percent. In contrast, Hiratsuka et al. (2009) concluded that FTAs are neither well-known nor well utilised by Japanese firms when examining the impact of FTAs on their behaviour.

Hanson et al. (2002) estimate the relationship regarding trade in imported inputs for further processing between the United States' multinational parents and their affiliates in foreign countries. The results of this study indicate that demand for imported input by the affiliates is affected negatively by the host-country tariffs, host-country wage of unskilled workers, and host-country corporate income tax rates. In addition, factors such as host-country policies and characteristics (such as market size and the presence of export processing zones) also affect the demand for imported inputs. In this study, Hanson et al. (2003) also argued that a fall in trade barriers between countries as well as increases in factor price differences between countries can raise vertical specialization within multinational firms.

In his study on trade facilitation, Shepherd (2010) found that the role of tariffs is important (compared to non-tariffs) in reducing trade cost in both ASEAN and Asia-Pacific Economic Corporation (APEC). In this study, he suggested that ASEAN and APEC should give more focus and efforts in the future towards trade facilitation on non-tariff trade costs.

As to the impact of the exchange rate on vertical trade in East Asia, many have argued that exchange rate volatility has a negative impact on trade in East Asia. For instance, Thorbecke (2008) argued that exchange rate volatility can reduce locational benefits of cross border fragmentation by increasing uncertainty. In his study, he found that the flow of trade within countries in East Asia decreases due to exchange

rate volatility. Therefore, he suggested that efforts should be made to maintain stable exchange rates in this region in order to provide a stable financial environment for East Asian production networks to develop. Besides, Hayakawa and Kimura (2009) also argued that exchange rate volatility has a far more negative impact on machinery P&C compared to finished goods, a negative impact that is even greater than that due to tariffs.

The growth of vertical specialisation network would also have positive implications to the many countries involved. In the case of developing countries, many studies have found evidence that vertical specialisation has had a positive impact on these countries. For example, Lemoine and Unal-Kesenci (2002) have found that an increase in the import of P&C to China has also led to the transfer of technology to that country. Kimura and Obashi (2010) argued that by participating in the IPNs, it becomes much easier for developing countries to kick start industrialisation. Meanwhile, using Japanese firm-level data (1995, 1998 and 2001), Hayakawa et al. (2009c) found that the greater the gap of capital-labour ratio between fragmenting firms' home and overseas activities, the greater their cost efficiency improves. According to Kang et al. (2010) and Wakasugi (2007), the development of fragmentation can increase productivity by means of realising scale economies. In addition, the development of fragmentation may also increase wage rates in developing countries while at the same time lowering the wage rate in developed countries. This finally would narrow down the wage gap between developing and developed countries in the long run (Wakasugi, 2007).

The growth of vertical specialisation networks may also have a negative impact on some countries. For example, Feenstra and Hanson (2001), Strauss-Kahn (2002,

2004), and Tsafack and Parasnis (2010) all argued that vertical trade can cause inequalities as well as unemployment for unskilled workers in developed countries where unskilled workers wage relatively high.

IPNs have led to the continuing expansion of intra-regional trade in P&C within the East Asian region[22]. Accordingly, some researchers such as Athukorala (2005), as well as Athukorala and Yamashita (2006) have argued that this rapid development in intra-industry trade between countries in the East Asian region may have led to the phenomenon of decoupling[23]. However, other researchers such as Park and Shin (2009), and Park (2011) have argued that an increase in intra-regional trade is not necessarily associated with decoupling in East Asia. Park (2011) further argued that East Asia's rapid recovery from the 2008 economic crisis was not related to the decoupling thesis.

2.5 Conclusion

This chapter reviews the development of trade in East Asia from World War II until the emergence of globalisation in which IPNs have shaped the pattern of trade in this region. In addition, this chapter also reviews some of the theoretical literature related to the development of trade in this region as well as the empirical literature related to IPNs. In general, studies on the development of trade in East Asia seem to suggest that the pattern of trade among countries in this region has evolved over time *in tandem* with the industrial development in those same countries. Initially, trade between countries in this region is somewhat simple, mainly in terms of a one-way

[22]East Asia's share of intra-regional trade achieved a value of 42.5 percent in 2005 (Park, 2011).
[23]Decoupling refers to the phenomenon of a weakening of the impact of demand and supply shocks emanating from the advanced countries on the region's economic performance.

trade between developed countries and developing countries. However, as soon as most developing countries start to follow in the developed countries' footsteps by developing their own industrial sector, the pattern of trade between developed and developing countries have become increasingly complicated.

By measuring the degree of vertical specialisation, many studies suggest that IPNs have grown rapidly in the East Asian region since 1990which is in line with the improvement in competitiveness of most developing countries. They also envisage East Asia as a "factory" where the stages of production are scattered around the region. At the same time, countries in this region seem to specialise vertically in the production chain. Previous studies have argued that the development of IPNs in East Asia was stimulated by many factors such as reduction in trade costs, better infrastructure, trade policies, etc. However, to fully understand the properties, nature and implication of IPNs, more empirical works with better data are needed.

Although many studies have suggested that East Asian countries tend to specialise vertically in the international production chain, to my knowledge, there is no study to date which has specifically sought to identify the position of each Asian country in that vertical chain. Realising that both vertical flying geese theory and spiral development model seem serve to identify the changing in role of countries, this thesis attempt to provide a method to identify the role of countries within the vertical specialisation framework. Consequently, based on the role(s) played by each country, this thesis will investigate the position of each East Asian country in the vertical production networks with special reference to the automobile industry.

CHAPTER 3 : TRADE DATA AND THE RECONCILIATION PROCESS

3.1 Introduction

In research, a reliable dataset is crucial towards obtaining accurate results. Nonetheless, the existence of asymmetry imports and exports data, obtained from the UN Comtrade, has become an obstacle to conducting empirical analyses in this thesis. Moreover, many researchers such as Yeat (1995) have argued that the direct use of trade data published by the UN Comtrade leads to problems of bias due to the data asymmetry. Therefore, the aim of this chapter is to provide a reliable dataset to be used in the empirical analysis of the later chapters. To do so, we adopt the reconciliation strategy developed by Gehlhar (1996). We opted for this strategy because it could deal effectively with issues related to data discrepancies reported by exporting and importing countries in choosing a reliable reporter.

This chapter is structured as follows: Section 3.2 describes the data and their sources. Section 3.3 discusses inconsistencies in the reported data from the UN Comtrade, while Section 3.4 discusses the process of data reconciliation. Section 3.5 discusses the selected results. The final section draws the conclusions.

3.2 Data description and sources

In this thesis, the empirical analyses in Chapters 4, 5 and 6 used international trade statistics from the UN Comtrade since those have the advantage of accessibility and

comparability across countries, thereby allowing us to identify countries' relationships with their trading partners. Apart from recent improvements in the UN Comtrade data reporting system, the international trade statistics also provide a consistent and comprehensive coverage of international production sliced trade (Athukorala and Menon, 2010). For product classification, we chose SITC Revision 2 due to the following reasons. Firstly, unlike the SITC Revision 1, SITC Revision 2 is detailed enough to distinguish traded P&C from finished products. It also has detailed commodity classification, particularly in the machinery and transport goods (SITC 7) (Kimura, 2007; Yeat, 2001; Athukorala and Menon, 2010). Secondly, unlike the HS and SITC Revision 3, SITC Revision 2 provides the broadest country and period coverage (Kimura, 2007; and Lall et al., 2004), thereby allowing one to analyse trade in final goods and P&C between 1990 and 2010[24].

As mentioned in Chapter 1, the focus of this thesis is the automobile industry. Accordingly, this thesis defines automobile P&C as items classified as "parts" and "accessories" or items not used as consumption goods or investment goods, while final automobiles are defined as complements of auto P&C and these items will be used as consumption goods or investment goods. Commodities included under automobile P&C are 7841 (chassis fitted with engines for vehicles of headings 722, 781-783), 7842 (bodies for vehicles of headings 722, 781-783), and 7849 (other parts and accessories for vehicles headings 722, 781-783). Commodities under final automobiles comprise 7223 (track-laying tractors), 7224 (wheeled tractors other than 74411-work trucks of the type use in factories, dock area, etc., and 7832-road tractors for semi-trailers), 7810 (passenger motor vehicles excluding buses), 7821 (motor vehicles for the transport of goods or materials), 7822 (special purpose motor lorries

[24]Data for Vietnam between 1990 and 1996 is unavailable as the country only began to report its trade data in the UN Comtrade since 1997.

and vans), 7831 (public service type passenger motor vehicles), and 7832 (road tractors for semi-trailers).

The main focus of our study is the following East Asian countries: Japan, China, Republic of Korea, and ASEAN (i.e., Thailand, Indonesia, Malaysia, the Philippines, Singapore, and Vietnam). Japan and the Republic of Korea are Asia's largest automobile producers, while China is an emerging market for the global giant-automakers and one of Asia's biggest markets for automobiles. In Asia's southeast region, Thailand is a major base for vehicle assemblers from developed countries, and its automobile industry is the largest among ASEAN economies. Although the growth and development of the automobile industry in other ASEAN countries (i.e., Indonesia, Malaysia, the Philippines, Singapore, and Vietnam) are not as drastic as those discussed above, their automobile industry is currently experiencing steady growth. To see the impact of East Asia's automobile industry on other regions and vice versa, we include the North American Free Trade Agreement (NAFTA), European Union (EU), and the rest of the world (ROW) in our analysis.

Other countries in this region such as Brunei Darussalam, Myanmar, Laos PDR, Cambodia, and Mongolia are not included in the study due to data limitations. In addition, these countries are also not significant players in regional and international trade of auto P&C in comparison to the rest. Taiwan is also not included since Taiwan is not a member of the UN and the UN Comtrade data system does not recognise her as a separate country. We take 1990 as the starting point because IPNs only began to be actively developed, especially in Southeast Asia, in the early 1990s. The year 2010 is taken as this study's endpoint since it represents the most recent year in which data for Vietnam can be found.

3.3 Inconsistency of reported data in the UN Comtrade

Although the UN Comtrade is the most comprehensive database in world trade, the data reported by each country in the database is somewhat inconsistent. This is because the export values reported by each country might not coincide with the corresponding import values reported by its partner. These differences are due to factors such as valuation[25], differences in inclusion or exclusion of particular commodities, and timing[26] (UN Comtrade). Tables 3.1 and 3.2 compare East Asian countries' reported imports of auto P&C with their partners' corresponding reported exports, while Tables 3.3 and 3.4 compare East Asian countries' reported imports of final automobiles with their partners' corresponding reported exports. Based on those tables, in some cases, large discrepancies between import and export values seem to exist. Logically, the value of imports at CIF prices minus the value of transport service equals the value of exports at FOB prices. However, the reported value of imports in the UN Comtrade database can be significantly smaller or several times larger than the reported value of exports in a given bilateral transaction.

To compare the size of these differences, we report the ratio between imports of auto P&C and the corresponding exports of those products for each country pair in 2010 (refer to Table 3.5). We also provide the same report of that ratio for final automobiles, as shown in Table 3.6. These tables clearly show that there is some conflict, for example, the trade data between the Philippines and the Republic of Korea reveal that imports reported by the Philippines are almost six times greater than the corresponding exports reported by the Republic of Korea. On the other hand,

[25]Trade transactions may be reported in different currencies by countries. This may have resulted in the exchange rate conversion problem since the UN Comtrade database reports them in US dollars.
[26]Imports and exports may be recorded in different time periods if a substantial transit period is required (Yeats, 1995).

trade data between Singapore and the Republic of Korea show that the imports reported by Singapore are one hundred times (i.e., 1/0.01=100) smaller than the exports reported by the Republic of Korea. In the case of final automobiles, the trade data between the Philippines and the Republic of Korea in 2010 show that imports reported by the Philippines are at least 17.5 times greater than the corresponding reported exports by the Republic of Korea. In the same year, the trade data between Malaysia and China show that imports reported by Malaysia are fifty times (i.e., 1/0.02=50) smaller than the exports reported by China.

Table 3.1: Imports of Automobile P&C among East Asian Countries in 2010

Import Values (US$ million)									
Country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN
JPN		454.7	1602.0	574.7	232.1	184.2	44.8	3.6	261.7
KOR	1339.3		990.9	28.2	2.1	9.8	5.8	3.3	12.1
CHI	7789.8	2275.2		55.0	60.7	9.4	59.6	5.1	17.4
THA	3636.8	188.2	156.0		259.8	360.9	90.3	98.6	15.3
IND	820.0	37.6	85.6	660.3		31.6	81.2	24.2	5.8
PHI	198.3	7.9	8.9	55.0	55.4		9.0	7.6	2.7
MAL	522.4	26.5	103.0	601.3	151.8	15.4		5.7	1.9
SIN	396.2	28.1	50.9	58.5	30.1	48.3	142.9		8.2
VN	189.8	182.4	133.7	173.2	39.3	23.4	4.5	3.0	

Table 3.2: Exports of Automobile P&C among East Asian Countries in 2010

Export Values (US$ million)									
country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN
JPN		485.8	1794.8	590.9	243.9	331.3	60.0	27.3	213.4
KOR	1258.1		886.2	32.2	1.1	1.7	1.4	605.3	5.9
CHI	7891.6	3575.4		43.6	36.2	62.9	50.5	160.8	43.5
THA	3338.7	151.8	238.5		290.9	451.6	108.7	105.9	14.6
IND	1397.6	48.1	112.2	535.3		98.1	142.7	255.7	22.8
PHI	432.1	31.5	80.4	163.1	76.4		14.8	35.3	6.7
MAL	1083.1	53.8	308.6	532.5	150.9	32.5		265.0	1.4
SIN	120.5	28.6	76.6	31.0	9.4	12.1	80.3		6.0
VN	136.4	223.5	116.0	157.1	34.0	53.8	6.4	19.6	

Table 3.3: Imports of Final Automobiles among East Asian Countries in 2010

Import Values (US$ million)	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN
	JPN		26.5	15.5	373.8	132.6	0.1	0.6	0.1	0.1
	KOR	632.2		8.8	0.7	0.2	0.1	0.0	0.0	0.5
	CHI	7590.4	1608.8	1.0	2.1	0.8		1.4		0
	THA	925.5	73.2	54.0	13.1	206.5	117.7	66.3	16.7	0
	IND	2394.7	50.7	58.8	1205.3	0.1	8.3	30.0	56.5	0.1
	PHI	479.9	181.8	38.2	1071.6	184.8		1.4	6.5	0.1
	MAL	1791.4	104.8	81.3	874.5	67.9	6.5		0.1	0.0
	SIN	433.2	113.4	39.8	43.9	2.7	0.1	41.4		0
	VN	182.1	320.2	154.8	53.4	5.6	0.2	1.0		-

Table 3.4: Exports of Final Automobiles among East Asian Countries in 2010

Export Values (US$ million)									
Country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN
JPN		25.5	18.7	400.2	124.5	0.1	0.7	0.9	0.4
KOR	617.2		9.3	0.7	0.1	0.0	0.2	0.2	0.1
CHI	7063.5	1580.6		24.8	0.6	0.1	75.0	3.9	0.3
THA	956.0	96.8	70.3		181.4	111.9	69.0	17.0	0.1
IND	1504.8	64.4	65.2	1188.3		8.8	35.5	445.2	0.1
PHI	610.7	330.0	68.6	832.5	132.7		0.4	6.0	0.1
MAL	1299.4	248.1	75.2	654.8	88.0	5.3		41.3	0.1
SIN	328.2	103.3	39.0	48.6	8.2	0.2	7.4		0.1
VN	194.9	649.8	350.1	45.4	13.6	0.6	1.1	2.4	

The import-export ratio values are useful for distinguishing the matched reported imports and exports from the unmatched ones. Based on the ratio values reported in Tables 3.5 and 3.6, it is obvious that the trade data obtained from UN Comtrade is inconsistent and not reliable for direct use. In order to ensure that all bilateral trade data used in this thesis are consistent, we reconciled the existing data using the procedures of Gehlhar (1996).

Table 3.5: Automobile P&C - Imports/Exports

country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN
JPN		0.94	0.89	0.97	0.95	0.56	0.75	0.13	1.23
KOR	1.06		1.12	0.87	1.90	**5.87**	4.19	**0.01**	2.05
CHI	0.99	0.64		1.26	1.68	0.15	1.18	0.03	0.40
THA	1.09	1.24	0.65		0.89	0.80	0.83	0.93	1.04
IND	0.59	0.78	0.76	1.23		0.32	0.57	0.09	0.25
PHI	0.46	0.25	0.11	0.34	0.72		0.61	0.21	0.40
MAL	0.48	0.49	0.33	1.13	1.01	0.48		0.02	1.34
SIN	3.29	0.98	0.66	1.89	3.21	4.01	1.78		1.36
VN	1.39	0.82	1.15	1.10	1.16	0.44	0.70	0.16	

Table 3.6: Final Automobiles - Imports/Exports

country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN
JPN		1.04	0.83	0.93	1.07	1.65	0.96	0.06	0.29
KOR	1.02		0.94	1.00	2.31	**17.57**	0.20	0.18	3.36
CHI	1.07	1.02		0.08	1.36	0	**0.02**	0	0
THA	0.97	0.76	0.77		1.14	1.05	0.96	0.98	0
IND	1.59	0.79	0.90	1.01		0.94	0.85	0.13	1.06
PHI	0.79	0.55	0.56	1.29	1.39		3.26	1.09	1.34
MAL	1.38	0.42	1.08	1.34	0.77	1.22		0	0.03
SIN	1.32	1.10	1.02	0.90	0.33	0.36	5.62		0
VN	0.93	0.49	0.44	1.18	0.41	0.29	0.90	0	

Some studies such as Athukorala and Yamashita (2006), Athukorala (2010), as well as Athukorala and Menon (2010) used the value of reported imports rather than that of reported exports when dealing with issues of inconsistency in the reported data of the UN Comtrade database. In this respect, they argued that the value of reported imports is more appropriate than that of exports for reasons such as importer records are admittedly less susceptible to double counting, erroneous identification of source/destination country in the presence of entrepot trade compared to data based on reporting country's records (e.g., China's trade via Hong Kong), and some countries fail to properly report goods shipped from their own export processing zones. In this thesis, however, Gehlher's procedure has been chosen because this procedure is able to select the data (either the volume of exports or that of imports)

reported by the most reliable reporter (either exporter or importer). In this respect, we believe that Gehlher's procedure deals more effectively with issues related to data discrepancies.

3.4 Data reconciliation

The reconciliation of bilateral trade data is aimed at resolving the inconsistency in the existing reported data. In this treatment process, we choose the data reported by the most reliable reporter using the reliability indices adopted from Gehlhar (1996). These indices are developed by taking into account how well a country reports all of its trading with partners[27]. Before constructing the reliability index, we implement the following steps with the existing data:

1. Since there are cases where the trade flow is only reported by one partner, we drop all observations where only one partner reports the trade flow. This treatment seems appropriate as it will enable us to calculate the accuracy level which will be explained later.
2. Import values in existing data are reported in *cif*, while export values are reported in *fob*. To eliminate the *cif/fob* transport margin, we convert import values reported on a *cif* basis to the *fob* basis using a *cif/fob* conversion factor of 1.10 (i.e., imports *cif* / 1.10). In this respect, the 10 percent *cif/fob* factor represents a simplified estimate of the costs of freight and insurance, as has been adopted in the IMF database.

[27]Some 204 countries are involved in this analysis. See Annex Table 3.1.

3. After converting import values from the *cif* basis to the *fob* basis, we then calculate the accuracy level (AL) of each transaction using the following formula:

$$AL_{i,r,s}^{fob} = \left| \frac{M_{i,r,s}^{fob} - X_{i,r,s}^{fob}}{M_{i,r,s}^{fob}} \right| \qquad (3.1)$$

where,

$M_{i,r,s}^{fob}$ is the value of imports reported by the importer of commodity *i* that is exported from country *r* to country *s*.

$X_{i,r,s}^{fob}$ is the value of exports reported by the exporter of commodity *i* from country *r* to country *s*.

The modulus (absolute value) in the above formula indicates that only the magnitude of the difference matters, not the sign. AL takes the value zero when the reported figures perfectly match, and increases as they diverge. Since there is no perfect match, some small discrepancies are trivial enough to be considered as accurate matches. In this respect, we follow Gehlhar (1996) by taking a threshold of 20 percent to identify accurate partner matches between imports and exports. Thus, the value of AL within the range of ±20 percent is considered matched. Outside this range, we consider it as unmatched.

Next, we construct a reliability index which is importer-commodity specific. We implement the following steps:

1. Calculate the total imports reported by importer *s* for commodity *i*

$$M_{i,s}^{T} = \sum_{r} M_{i,r,s}^{fob} \qquad \forall s \qquad (3.2)$$

2. Calculate the reported imports that accurately matched with the partner's reported export value, denoted as:

$$M_{i,s}^{A} = \sum_{r} M_{i,r,s}^{fob} \qquad \forall s \text{ where } AL_{i,r,s}^{fob} \leq 0.20 \qquad (3.3)$$

3. Calculate the importer-commodity reliability index (RIM) as the share of accurate transactions, denoted as:

$$RIM_{i,s} = \frac{M_{i,s}^{A}}{M_{i,s}^{T}} \qquad \forall s \qquad (3.4)$$

where RIM takes the value of one when all reported imports for commodity *i* in country *s* are within the ±20 percent threshold of that reported by its partner, and are equal to zero when no reported imports is within the ±20 percent threshold of that reported by its partner. Likewise, to construct a reliability index that is exporter-commodity specific, we implemented the following steps:

1. First, calculate the total exports reported by exporter *s* for commodity *i*

$$X_{i,r}^{T} = \sum_{s} X_{i,r,s}^{fob} \qquad \forall r \qquad (3.5)$$

2. Next, calculate the reported exports that accurately matched with the partner's reported import value, denoted as:

$$X_{i,r}^{A} = \sum_{s} X_{i,r,s}^{fob} \qquad \forall r \text{ where } AL_{i,r,s}^{fob} \leq 0.20 \qquad (3.6)$$

3. Then, calculate the exporter-commodity reliability index (RIX) as the share of accurate transactions, denoted as:

$$RIX_{i,r} = \frac{X_{i,r}^{A}}{X_{i,r}^{T}} \qquad \forall s \qquad (3.7)$$

where RIX takes the value of one when all reported exports for commodity *i* in country *s* are within the ±20 percent threshold of that reported by its partner, and are equal to zero when no reported exports is within the ±20 percent threshold of that reported by its partner. For each trade pair, both the RIM and RIX values for countries involved will then be compared, and the country with the higher value will be chosen as the most reliable reporter and its value for the trade flow will be used.

Before calculating the reliability index (i.e., RIM and RIX), however, the opportunity will be given to each reporter to ignore any value reported by its worst partner. This can prevent reliable reporters who happen to trade with a large unreliable partner from having a bad record. To do so, any partner that produces the largest value-weighted accuracy level for both importer and exporter (VAL) will be dropped from their set of transactions. By dropping large and less accurate transactions, the reliability index for all countries will be enhanced. The formulae for value-weighted accuracy for both importer and exporter are as follows:

$$VAL^{M}_{i,r,s} = \frac{M^{fob}_{i,r,s}}{M^{T}_{i,r,s}} AL_{i,r,s} \tag{3.8}$$

$$VAL^{X}_{i,r,s} = \frac{X^{fob}_{i,r,s}}{X^{T}_{i,r,s}} AL_{i,r,s} \tag{3.9}$$

3.5 Selected results

Table 3.7 and Table 3.8 depict the selected results of reported values from importer and exporter, RIM, RIX, and the most reliable reporter for automobile P&C and final automobiles, respectively. Specifically, the former lays out the selected results for items with codes 7841 (i.e., chassis fitted with engines for vehicles of headings 722, 781-783), 7842 (i.e., bodies for vehicles of headings 722, 781-783), and 7849 (i.e.,

other parts and accessories for vehicles headings 722, 781-783), while the latter lays out the selected results for items with codes 7223 (i.e., track-laying tractors), 7224 (i.e., wheeled tractors other than 74411-work trucks of the type used in factories, dock area, etc., and 7832-road tractors for semi-trailers), 7810 (i.e., passenger motor vehicles excluding buses), 7821 (i.e., motor vehicles for the transport of goods or materials), 7822 (i.e., special purpose motor lorries and vans), 7831 (i.e., public service type passenger motor vehicles), and 7832 (i.e., road tractors for semi-trailers).

Based on the first row in Table 3.7, Indonesia as an importer country received an RIM of 0.324, which means that at least 32 percent of the values of item 7821 was reported accurately by Indonesia. Of the exporters' list for that item, its partner i.e., China, received an RIX of 0.191. Since the Chinese RIX is smaller than the Indonesian RIM of 0.324, we have rejected China's reported value of US$ 1.61 million and accepted Indonesia's reported value of US$ 0.27 million. In other words, for item 7821 the importer report (i.e., Indonesia) would be accepted as reliable data.

On the other hand, based on the first row in Table 3.8, Japan received an RIX of 0.558, while her partner, Singapore, received an RIM of 0.030 for item 7223. Since the Japanese RIX for that item is greater than the Singaporean RIM, we have rejected Singapore's reported value of US$ 0.81 million and accepted Japan's reported value of US$ 0.87 million. In this case, the exporter report (i.e., Japan) would be accepted as reliable data.

In some cases, the reliability index can be zero (refer to the first, second and third row in Table 3.7, and the second, third, fifth row in Table 3.8). This means that none

of the transactions were deemed accurate to be used in the calculation. In the examples listed, this was the case for the Vietnamese, Thai and Chinese imports of item 7841; Vietnamese and Thai imports of item 7223; and Filipino imports and Singaporean exports of item 7224. Therefore, all the reported imports of item 7841 by Vietnam, Thailand and China, the reported imports of item 7223 by Vietnam and Thailand, the reported imports of item 7224 by the Philippines, and the reported exports of item 7224 by Singapore would be reported by their own partners in the reconciled data.

Based on Table 3.7, both Thailand and Malaysia have a larger score of RIX for item 7842. In this respect, Thailand has the highest RIX of 0.874, while Malaysia enjoys a score of 0.838. We also accept Thailand's and Malaysia's reported values and reject their partners' reported values, as RIX for both countries are higher than their respectively partners' RIM. Meanwhile, for item 7849, Japan, Indonesia and Vietnam received better RIX scores. The scores of RIX for those countries are 0.773, 0.764 and 0.727, respectively (refer to Table 3.7). In addition, the reliability of China in reporting exports of item 7849 has also been better compared to any other items in the auto P&C list.

Table 3.7 also shows that the Philippines received a very low RIX of 0.027 for item 7849. This indicates that only 2.7 percent of the value of this product was reported accurately by the Philippines. When comparing the Philippines' RIX with its trading partners' RIM such as China (i.e., 0.800), Indonesia (i.e., 0.348) and Japan (i.e., 0.480), we can say that the Philippines over-reported exports of item 7849. Other than the Philippines, Singapore also received a lower score of RIX for that item. Meanwhile, in terms of RIM, almost all countries received a lower score in each

item. The only higher score was received by the Republic of Korea, Thailand, and Vietnam for item 7849 (refer to Table 3.7)

Table 3.7: Selected Examples of Reported and Reconciled Values of Auto P&C in 2010

Item Code	Importer	Exporter	Reported by Importer	Reported by Exporter	RIM	RIX	Most Reliable Reporter
7841	IND	CHI	272,586	1,610,251	0.324	0.191	IND
7841	SIN	CHI	216,087	42,400	0.001	0.191	CHI
7841	THA	CHI	3,155,424	4,546,895	0.000	0.191	CHI
7841	VN	CHI	71,518	6,607,671	0.000	0.191	CHI
7841	CHI	JPN	25,777,938	326,128	0.000	0.051	JPN
7842	THA	JPN	18,775,308	14,709,020	0.153	0.125	THA
7842	CHI	KOR	684,631	760,708	0.133	0.190	KOR
7842	CHI	MAL	28,266	342,333	0.133	0.838	MAL
7842	IND	MAL	227,334	42,743	0.026	0.838	MAL
7842	IND	THA	4,914	398,232	0.026	0.874	THA
7849	IND	CHI	76,929,109	108,800,000	0.348	0.459	CHI
7849	KOR	CHI	900,200,000	886,000,000	0.910	0.459	KOR
7849	JPN	IND	210,600,000	243,700,000	0.480	0.764	IND
7849	PHI	MAL	8,133,930	14,352,457	0.004	0.187	MAL
7849	CHI	PHI	8,544,533	62,851,193	0.800	0.027	CHI
7849	IND	PHI	28,684,814	98,127,497	0.348	0.027	IND
7849	JPN	PHI	167,400,000	331,200,000	0.480	0.027	JPN
7849	CHI	SIN	4,611,470	160,700,000	0.800	0.045	CHI
7849	KOR	SIN	2,955,836	605,200,000	0.910	0.045	KOR
7849	PHI	SIN	6,864,772	35,269,983	0.004	0.045	SIN
7849	VN	SIN	2,768,327	19,561,948	0.675	0.045	VN
7849	IND	VN	5,266,518	22,776,084	0.348	0.727	VN
7849	JPN	VN	237,900,000	213,400,000	0.480	0.727	VN

Table 3.9 shows the frequency of being a reliable reporter in each transaction for both auto P&C and final automobiles. Based on this table, Thailand, Japan, China, and Malaysia are the most frequent reliable reporters in the case of auto P&C. Of 135 transactions, Thailand and Japan became reliable reporters in about 25 and 22 of those transactions, respectively. In terms of ranking, Thailand and Japan occupied the first and second place respectively, while both China and Malaysia took third

place. In the case of final automobile, Table 3.9 shows that Japan and China are the most frequent reliable reporters, with both occupying first and second place, respectively.

Table 3.8: Selected Examples of Reported and Reconciled Values of Final Automobiles in 2010

Item Code	Importer	Exporter	Reported by Importer	Reported by Exporter	RIM	RIX	Most Reliable Reporter
7223	SIN	JPN	805,639	872,910	0.030	0.558	JPN
7223	THA	JPN	5,686,586	223,453	0.000	0.558	JPN
7223	VN	JPN	647,645	3,982,414	0.000	0.558	JPN
7224	JPN	IND	1,376,469	448	0.916	0.981	IND
7224	PHI	KOR	80,752	630,566	0.000	0.264	KOR
7224	MAL	SIN	19,042	585,405	0.385	0.000	MAL
7810	SIN	CHI	554,027	592,746	0.829	0.363	SIN
7810	JPN	IND	921,125	96,204,816	0.933	0.768	JPN
7810	PHI	JPN	259,400,000	230,600,000	0.855	0.697	PHI
7810	PHI	KOR	93,101,144	222,700,000	0.855	0.722	PHI
7810	IND	PHI	7,543,677	8,845,615	0.547	0.932	PHI
7810	KOR	PHI	79,871	5,000	0.237	0.932	PHI
7821	CHI	JPN	596,000,000	665,100,000	0.729	0.432	CHI
7821	PHI	KOR	4,372,940	37,229,952	0.004	0.465	KOR
7822	KOR	CHI	406,433	458,913	0.009	0.387	CHI
7822	SIN	IND	1,142,268	326,950	0.376	0.000	SIN
7831	IND	JPN	30,485,731	3,024,657	0.017	0.495	JPN
7831	MAL	JPN	48,629,317	61,568,931	0.011	0.495	JPN
7832	JPN	CHI	102,985	740,699	0.035	0.104	CHI
7832	VN	MAL	886,545	861,204	0.230	0.952	MAL
7223	KOR	JPN	27,993	4,238,862	0.913	0.558	KOR

Table 3.9: The Rank of Reliable Reporter for Auto P&C and Final Automobiles in 2010

Country	Auto P&C			Final Automobiles		
	Frequency	Percent	Rank	Frequency	Percent	Rank
JPN	22	16.3	2	47	19.5	1
KOR	19	14.07	4	31	12.86	3
CHI	20	14.81	3	37	15.35	2
THA	25	18.52	1	30	12.45	4
IND	13	9.63	5	24	9.96	5
PHI	2	1.48	8	19	7.88	7
MAL	20	14.81	3	24	9.96	5
SIN	4	2.96	7	21	8.71	6
VN	10	7.41	6	8	3.32	8
Total	135	100	-	241	100	-

3.6 Conclusion

This thesis uses international trade statistics published by the UN Comtrade due to advantages such as their accessibility, comparability across countries, as well as their comprehensive coverage of international production sliced trade. Nevertheless, data reported in that database are inconsistent and not reliable for direct use. Since analyses in this thesis require consistency between the export flow and its corresponding imports for all partner pairs, we carried out a reconciliation of the original data by adopting the procedures of Gehlhar (1996).

Annex to Chapter 3

Annex Table 3.1: List of Countries Involved in the Reconciliation Process

Country			
Afghanistan	China	Guinea	Marshall Islands
Albania	Colombia	Guyana	Mauritania
Algeria	Comoros	Haiti	Mauritius
American Samoa	Congo, Dem. Rep.	Honduras	Mayotte
Andorra	Congo, Rep.	Hong Kong	Mexico
Angola	Costa Rica	Hungary	Micronesia, Fed. Sts.
Antigua and Barbuda	Cote d'Ivoire	Iceland	Moldova
Argentina	Croatia	India	Mongolia
Armenia	Cuba	Indonesia	Montenegro
Aruba	Cyprus	Iran, Islamic Rep.	Morocco
Australia	Czech Republic	Iraq	Mozambique
Austria	Denmark	Ireland	Myanmar
Azerbaijan	Djibouti	Israel	Namibia
Bahamas, The	Dominica	Italy	Nepal
Bahrain	Dominican Republic	Jamaica	Netherlands Antilles
Bangladesh	Ecuador	Japan	Netherlands
Barbados	Egypt, Arab Rep.	Jordan	New Caledonia
Belarus	El Salvador	Kazakhstan	New Zealand
Belgium	Equatorial Guinea	Kenya	Nicaragua
Belize	Eritrea	Kiribati	Nigeria
Benin	Estonia	Korea, Dem. Rep.	Niger
Bermuda	Ethiopia	Korea, Rep.	N. Mariana Isds
Bhutan	Faeroe Islands	Kuwait	Norway
Bolivia	Fiji	Lao PDR	Oman
Bosnia and Herzegovina	Finland	Latvia	Pakistan
Botswana	France	Lebanon	Palau
Brazil	French Polynesia	Lesotho	Panama
Brunei Darussalam	Gabon	Liberia	Papua New Guinea
Bulgaria	Gambia, The	Libya	Paraguay
Burkina Faso	Georgia	Lithuania	Peru
Burundi	Germany	Luxembourg	Philippines
Cambodia	Ghana	Macao	Poland
Cameroon	Gibraltar	Macedonia	Portugal
Canada	Greece	Madagascar	Qatar
Cape Verde	Greenland	Malawi	Romania
Cayman Islands	Grenada	Malaysia	Russian Federation
Central African Republic	Guam	Maldives	Rwanda
Chad	Guatemala	Mali	Samoa
Chile	Guinea-Bissau	Malta	San Marino

Country			
Sao Tome and Principe	Sri Lanka	Timor-Leste	United States
Saudi Arabia	St. Kitts and Nevis	Togo	Uruguay
Senegal	St. Lucia	Tonga	Uzbekistan
Serbia	St. Vincent and the Grenadines	Trinidad and Tobago	Vanuatu
Seychelles	Sudan	Tunisia	Venezuela, RB
Sierra Leone	Suriname	Turkey	Vietnam
Singapore	Swaziland	Turkmenistan	Yemen, Rep.
Slovak Republic	Sweden	Turks and Caicos Isds	Zambia
Slovenia	Switzerland	Tuvalu	Zimbabwe
Solomon Islands	Syrian Arab Republic	Uganda	
Somalia	Tajikistan	Ukraine	
South Africa	Tanzania	United Arab Emirates	
Spain	Thailand	United Kingdom	

CHAPTER 4 : VISUALISING THE STRUCTURE OF EAST ASIA'S AUTOMOBILE PRODUCTION NETWORKS

4.1 Introduction

Over the past six decades, trade in the East Asian region has continued to grow by leaps and bounds. According to Kimura (2006), East Asia's trade pattern rapidly shifted from one-way trade to intra-industry trade, while trade in machinery parts and components expanded significantly since the early 1990s due to reduction in trade costs as well as advancements in ICT. In machinery products, the share of one-way trade for Japan, China, Thailand, and Malaysia between 1990 and 2000 decreased from 46 to 26 percent, 52 to 27 percent, 57 to 21 percent and 32 to 18 percent, respectively. In contrast, in the same period the share of intra-industry trade for those countries increased from 54 to 74 percent, 48 to 73 percent, 43 to 79 percent and 68 to 82 percent, respectively. At the same time, less developed countries in East Asia have begun to export manufacturing products and are involved actively in the IPNs. These circumstances have led many researchers (such as Kimura and Obashi, 2010; and Ferrarini, 2011) to focus more on changes in the structure of trade in the region.

This chapter investigated automobile production in East Asia, seeking to explain how it has evolved from 1990 to 2010 to become a hub for global production. Firstly, the major role played by each country in East Asia's international automobile production chain is explored by examining their terms of trade in automobile P&C and final goods. Secondly, each country's main trading partners are identified to illustrate the

trade network and dependencies between countries. Lastly, the evolution of this trade network is investigated in terms of how countries' roles, trading partners and network patterns have changed for the years 1990, 1995, 2000, 2005 and 2010.

This chapter is organised as follows: Section 4.2 discusses recent developments in the global automobile industry, which has provided us with the motivation to carry out a qualitative study. Section 4.3 discusses the various stages in the production of automobiles, while Section 4.4 looks at the research methodology. Section 4.5 then discusses the findings from both country-level and network-level analyses, before Section 4.6 draws this chapter to a conclusion.

4.2 Scenario in the global automobile industry

The automobile industry has become one of the most important contributors to economic growth in many countries. Apart from generating employment opportunities[28], the industry also enables other industrial sectors to grow. According to Nag et al. (2007), the Japanese automobile industry represents 13 percent of Japan's total manufacturing output and 10 percent of its national employment in 1999. In the same period, some 41 percent of the Republic of Korea's total motor vehicle production have been exported abroad, and which contributed 3.7 percent to its GDP. In the USA, the automobile industry accounted for over 5 percent of its private sector GDP in 2002. In the same period, this industry also contributed around 9 percent to the EU manufacturing sector.

[28]The automobile sector has employed around 20 million workers around the world who are involved in the production of auto P&C, production of final automobiles, as well as selling and servicing final automobiles (Dicken, 2003).

There are many global companies involved in automobile production. To enhance competitiveness, auto-giants such as General Motors, Toyota, and Volkswagen have moved their production base to developing countries such as China, India, four countries within the Association of Southeast Asian Nations (ASEAN) (viz. Indonesia, Malaysia, Thailand and the Philippines), Argentina, Brazil, and countries in Central Europe (Czech Republic, Hungary, and Poland), in order to take advantage of cheaper labour. Furthermore, local parts production can meet short delivery times adapted to the local demand and avoid exchange rate fluctuations (Doner et al., 2004). The shift in production location from developed to developing countries has caused the production and sales in developing countries to grow drastically. For instance, between 1990 and 1997, while vehicle production and sales in the Triad regions (i.e., North America, Japan and Western Europe) increased by 4.2 and 0.6 percent respectively, emerging markets' production and sales increased by 93.1 and 80.1 percent respectively (Humphrey and Memedovic, 2003).

In fact, the conspicuous growth in the non-Triad regions concentrated on a number of fast-growing emerging markets, namely China, India, Republic of Korea, ASEAN, Brazil, Mexico, and Eastern Europe. In addition, the changing patterns of global automobile production also resulted in the emergence of Asia as a hub for global automobile production. In this respect, Asia has become a major supplier as well as a major consumer of automobile P&C. Based on the above discussion, we can say that the shift in production location from developed to developing countries has been a factor in the growing demand for auto products in emerging markets.

4.3 Production chain in the automobile industry

The rapid growth in the automobile industry in developing countries including the East Asian region started in earnest in the early 1990s (Humphrey and Memedovic, 2003) when most auto-giant companies extended their operations into developing countries to take advantage of the low production cost. Japanese automotive firms, for example, spread out their production all over the world, particularly in the Asian region. Thus, the automotive industry in Thailand has been driven by Japanese FDI[29] which focused entirely on the export market. Among Japanese automotive firms that operate in Thailand are Siam Toyota Manufacturing (STM) and Toyota Auto Body (TABT). STM specialised in producing engines, while TABT is involved in the manufacture and stamping of body panel as well as body assembly and paint for Toyota[30]. In the Philippines, Japanese automobile firms such as Toyota Motor, Isuzu Motors, Mitsubishi Motors, Nissan Motors, and Honda Cars dominate the automobile industry in that country (Aldaba, 2007). Toyota Auto Parts Philippines Inc. (TAP), for example, has specialised in producing transmission for the world market. Meanwhile, in Indonesia it was reported that Japanese automakers (i.e., Toyota, Mitsubishi, Suzuki, Isuzu and Daihatsu) have acquired a bigger share of sales there, whereby more than 80 percent of all new passenger cars and commercial vehicles sales have been claimed by those companies (Nag et al., 2007).

As an assembly industry, the automobile industry actually brings together hundreds of thousands of components manufactured by different firms in different industries. In general, there are three major processes prior to assembling the final vehicle. The

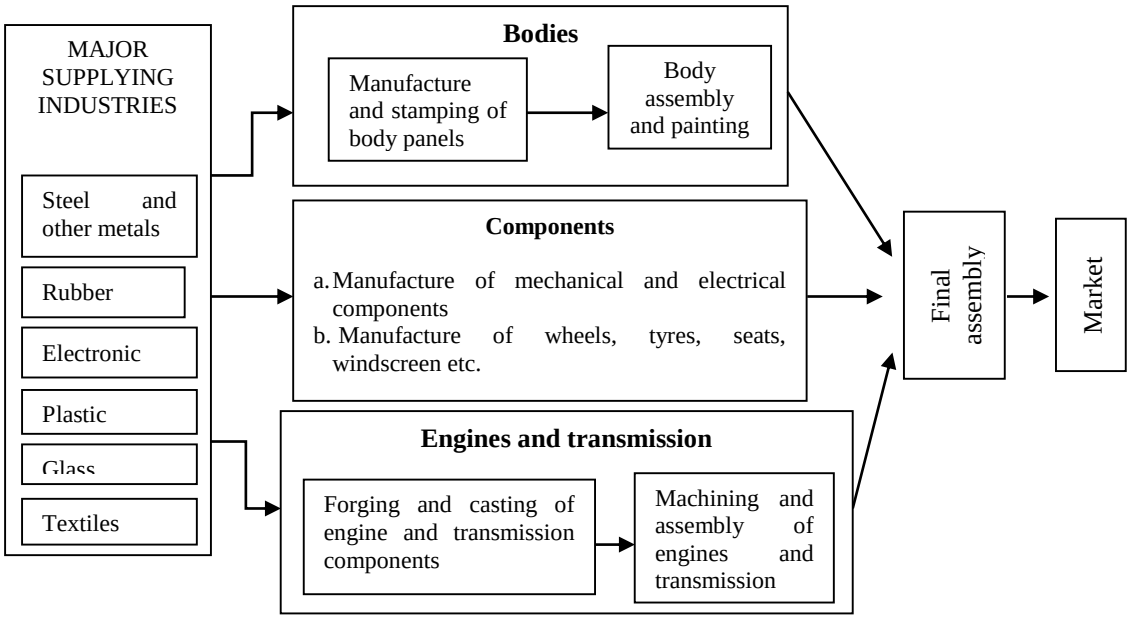
[29]Japanese firms have more than a 90 percent vehicle market share in Thailand, where nearly 30 percent of which is controlled by Toyota (Dicken, 2003).
[30]Based on data from Toyota Motor Corporation, 2009.

processes comprise manufacturing of bodies, manufacturing of components, and manufacturing of engine and transmissions. Figure 4.1 illustrates the production chain process, from the raw material through several stages of processing until it finally reaches the market. In producing car bodies, the first processing stage involves the manufacture and stamping of body panel. Then, the second processing stage is the assembling and painting of the car's body before it enters the final assembly process. In producing components, the first stage involves the following processes: (1) manufacture of mechanical and electrical components (e.g. instruments, carburettors, braking systems, steering components, etc.); (2) manufacture of wheels, tyres, seats, windscreens, exhaust systems, etc. These components will be used further in the final assembly. In producing engines and transmissions, the first stage involves forging and casting engines and transmission components. The second stage in the manufacture of engines and transmission is machining and assembling of engines and transmissions. Inputs from the second stage will be used in the final assembly process. The finished vehicle from the final assembly process (final stage of production) would then be sold domestically or exported to a foreign market.

Therefore, if we trace back a Toyota car that someone is driving, let's say, in the UK, it is quite possible that it has undergone the process of production in various countries. If the car was imported from Thailand, thus the final assembly will have taken place in Thailand. Assembly activities (in Thailand) require P&C such as engine, body and related components. Therefore, those parts need to be purchased from a local supplier or otherwise imported from another country. For example, components such as steering, windscreen and electrical components might have been imported from China. The transmission might have been imported from the

Philippines, while the body and engine might have been purchased from local suppliers in Thailand, and so forth.

Figure 4.1: The Basic Automobile Production Chain



Source: Dicken (2003)

In general, most of East Asia's auto industry passes through four stages of development even though each stage of development varies from country to country. In the first stage, East Asian countries tend to import complete vehicles due to high transportation costs and import restrictions. This situation has been experienced by countries such as Thailand, Malaysia, and the Philippines in the early 1980s and Vietnam in the early 1990s. In the second stage, despite developing East Asian countries still importing vehicles from developed countries, the reduction in transportation costs provides them with the opportunity to make minor product modification for the local market. Consequently, in the third stage, assembly processes in developing East Asian countries involve a mix of imported and locally sourced components. This situation was experienced by countries such as Thailand and Malaysia in the late 1990s. This development is due to the role played by the

government in those countries. Finally, countries at the third stage will then move to the fourth stage whereby they are involved in full-scale local manufacturing.

4.4 Methodology

It is necessary to go beyond country-by-country descriptive analysis of trade flows in order to provide a clearer picture of the role of each country, its important trading partners, and its pattern of networks in the global auto industry. Furthermore, comprehending the information contained in country-by-country trade flow matrices is difficult; in this study, we use a graphical approach as an alternative so as to illustrate the evolution of trade patterns in East Asia. The advantages of using such a graphical approach is that it can be useful for analysing patterns as well as assisting researchers (and the public) to quickly comprehend their broad scope. For example, it can reduce computational burden by showing both the whole and the part or showing overall trends with more specific details (Howard, 2009a).

In this graphical approach, we conduct two types of analyses, namely, country-level analysis and a bilateral network analysis. The former is used to examine role(s) played by each country as well as its major trading partners. In this analysis, we identify the important linkages for either the source or destination country by employing a two-step procedure. First, we attempt to identify whether total trade in terms of the export or import of automobile P&C and/or export or import of final automobiles is important for a particular country[31]. Second, if it is considered to be

[31]These indices assume that trade flows are important in relative rather than absolute terms. This is because the use of absolute terms tends to ignore the participation of small economies such as Vietnam in the IPNs, as their value of export (import) is very small compared to big economies such as Japan and China.

an important trade flow, then we attempt to identify the major countries where this linkage exists. Consequently, information from the above procedure will be presented in quadrant diagrams at the country-level analysis. Finally, we put all the countries together to produce network diagrams that show the pattern of linkages in the automobile industry. This allows one to consider the possible production chains that might exist between countries.

4.4.1 Identifying important trade flows

There are four possible roles which could be played by each country: it might be an important exporter of automobile P&C; an important importer of automobile P&C; an important exporter of final automobiles; or an important importer of final automobiles. To identify which trade role is important for each country, we developed an Export Intensity Index (XII) and Import Intensity Index (MII) for both auto P&C and final automobiles. The XII measures country A's total exports of auto P&C (final automobiles) in terms of its total trade in the automobile industry, while the MII measures country A's total imports of auto P&C (final automobiles) in terms of its total trade in the automobile industry. These four indices sum to one and provide an indication of the trade structure in the automobile industry[32]. Formulae for such indices may be laid out as follows:

XII for auto P&C: $\frac{\sum X^{A}_{P\&C}}{T^{A}_{P\&C}+T^{A}_{FG}}(100)$

MII for auto P&C: $\frac{\sum M^{A}_{P\&C}}{T^{A}_{P\&C}+T^{A}_{FG}}(100)$

[32]Those indices have been developed by adapting the international competitiveness index [i.e. (exports-imports)/(exports+imports)].

XII for final automobiles: $\frac{\sum X^{A}_{FG}}{T^{A}_{P\&C}+T^{A}_{FG}}(100)$

MII for final automobiles: $\frac{\sum M^{A}_{FG}}{T^{A}_{P\&C}+T^{A}_{FG}}(100)$

where,

$X^{A}_{P\&C}$ = country A's export of auto P&C to its partners.

$M^{A}_{P\&C}$ = country A's import of auto P&C from its partners.

X^{A}_{FG} = country A's total export of final automobiles to its partners.

M^{A}_{FG} = country A's total import of final automobiles from its partners.

$T^{A}_{P\&C} = \sum X^{A}_{P\&C} + \sum M^{A}_{P\&C}$

$T^{A}_{FG} = \sum X^{A}_{FG} + \sum M^{A}_{FG}$

4.4.2 Identifying important partners

To identify the important import and export partners for each country, we develop an Export Share Index (XSI) and Import Share index (MSI) for both auto P&C and final automobiles. The XSI measures country A's exports of auto P&C (final automobiles) to country B as a share of its total exports of auto P&C (final automobiles), while the MSI measures country A's imports of auto P&C (final automobiles) from country B as a share of its total imports of auto P&C (final automobiles). These indices help differentiate those important partners from other minor partners using the following formulae:

XSI for auto P&C= $\frac{X^{A,B}_{P\&C}}{X^{A,W}_{P\&C}}(100)$

XSI for final automobiles = $\frac{X_{FG}^{A,B}}{X_{FG}^{A,W}}(100)$

MSI for auto P&C = $\frac{M_{P\&C}^{A,B}}{M_{P\&C}^{A,W}}(100)$

MSI for final automobiles = $\frac{M_{FG}^{A,B}}{M_{FG}^{A,W}}(100)$

where,

$X_{P\&C}^{A,B}$ = country A's exports of auto P&C to country B

$M_{P\&C}^{A,B}$ = country A's imports of auto P&C from country B

$X_{P\&C}^{A,W}$ = country A's total export of auto P&C

$X_{FG}^{A,B}$ = country A's exports of final automobiles to country B

$M_{FG}^{A,B}$ = country A's imports of final automobiles from country B

$X_{FG}^{A,W}$ = country A's total export of final automobiles

To capture the major linkages without complicating the diagrams with minor links, we explored a number of alternative cut-offs before selecting 15 percent for XII, MII, XSI and MSI on the basis that an appropriate number of links were captured. Sensitivity analyses of 12 and 18 percent were also implemented to explore the robustness of the conclusions to what essentially was an arbitrary cut-off point (see Annex Figure 4.1).

4.4.3 The quadrant diagrams

The important role played by each country as well as their important trading partners during the period 1990-2010 is presented in the form of quadrant diagrams. The first quadrant in each quadrant diagram represents the exports of auto P&C. This quadrant

provides information such as the value of total export of auto P&C abroad (total value of the 1st quadrant) and the share of total export of auto P&C abroad in terms of the total automobile trade (in percentage) plus the major destinations for auto P&C. The second quadrant in each diagram represents the imports of auto P&C. This quadrant also provides information such as the value and share of total import of auto P&C in terms of the total automobile trade (in percentage) plus the major sources of auto P&C. The import of final automobiles is represented by the third quadrant, which provides information such as the value of total import of final automobiles worldwide, the share of total import of final automobiles in terms of the total automobile trade (in percentage), plus the most important countries that export final automobiles to a country's market. The fourth quadrant in each figure is devoted to the exports of final automobiles and provides information such as the value of total export of final automobiles abroad, the share of total exports of final automobiles in terms of the total automobile trade (in percentage), plus the major importers of these final automobiles.

A quadrant is considered important if the share of quadrant in terms of the total automobile trade is greater than the 15 percent threshold. In this respect, we used black bold arrows to indicate that the quadrant is important. On the other hand, if any quadrants are not important, they are represented by a white arrow. Meanwhile, a link between a country and its partners is considered important if the value of the share of exports or imports (depending on which quadrant we are referring to) between that country and its partners (compared with the total quadrant) is greater than the 15 percent threshold. However, if the quadrant as a whole is not considered important, then no link with any particular country in this quadrant is considered important.

4.4.4 International production chain and expected trade relationship

In this section, we further develop a method to examine the pattern of linkages in the automobile industry. This pattern of linkages helps identify the position of each country in the IPNs in this industry, as well as the development of this network over the past 20 years. In order to examine the pattern of linkages, we analyse the bilateral relationships between each pair of countries. Following Piana (2006), we characterise bilateral relations in terms of four conditions, each of which will or will not hold with respect to trade in parts and components (PC) and in final goods (FG):[33]

a. For A's trading partner, A is a major export destination (market)
b. For A's trading partner, A is a major import source (supplier)
c. For A, its trading partner is a major export destination (market)
d. For A, its trading partner is a major import source (supplier)

Specifically, the value of 1 will be given to each condition if the condition is true (i.e., the quadrant is considered important and the value of exports or imports for a particular country is greater than the 15 percent threshold) or otherwise zero. Table 4.1 describes the nine distinct types of relationship that might occur between any pair of countries between which a certain link exists.

In the case of existing relationships in East Asia's automobile industry, we do not expect all of the above types of relationship to appear. In particular, we expect that there will be a predominance of dominance-dependence relationships between

[33]Piana (2006) applied the above methodology to the countries' total trade data to identify the world trade structure. Our study, however, differs from Piana (2006) since even though we use a similar methodology, we focus on a specific industry (i.e., automobile industry) and divide the industry into two markets, namely, auto P&C market and final automobiles, which allows us to describe the production chain and changes in the production chain within this industry.

developed (e.g. Japan) and developing (e.g. Thailand) countries. Besides, we also expect integration relationships (e.g. between NAFTA and Japan) as well as market dependence relationship (e.g. between Japan and EU). Given that this is the case, we can then identify the position of each country in an automobile industry international "vertical" production chain within the East Asian region.

Table 4.1: Possible Types of Relationship between Countries

Binary code	Description
0001 (0100)	A country relies upon its partner as an import source. This link is only important for one party (i.e., country in question but not its partner).
0010(1000)	A country relies upon its partner as a market destination. This link is only important for one party (i.e., country in question but not its partner).
0011(1100)	A country relies upon its partner as both import source and market. This link is only important for one party (i.e., country in question but not its partner).
0110(1001)	A country relies upon its partner as a market destination, while its partner relies on her as an import source. This link is important for both parties.
0101	Two countries rely upon each other as import sources. This link is important for both parties.
1010	Two countries rely upon each other as import markets. This link is important for both parties.
1111	Two countries rely upon each other in terms of both import source and market. This link is important for both parties.
0111(1101)	A country relies upon its partner in terms of both import source and market, while its partner relies on her as an import source. This link is important for both parties.
1011 (1110)	A country relies upon its partner in terms of both import source and market, while its partner relies on her as a market destination. This link is important for both parties.

Note: Codes in parentheses refer to the situation where the roles of the two countries are reversed

Accordingly, we define country A as:

- a "top" country if it is an export country in that other countries rely on its exports but it is not dependent on any one of its partners (as shown by codes

PC0100 and FG0100) or other countries rely on its exports and it is also reliant on these partners as important markets (shown by codes PC0110 and FG0110) or it relies on other countries' markets (shown by codes PC0010 and FG0010) or other countries rely on her for their source and market of auto P&C (shown by code PC1100). Moreover, for such a "top" country, imports of P&C or final goods from other countries are not important (shown by the absence of any of the code(s) in Table 4.4).

We further break up the "top" into "basic top" and "advanced top". "Basic top" refers to a country which only exports final automobiles abroad and therefore should not have any code(s) in the FG column in Table 4.2. The "advanced top" refers to a country which exports both auto P&C and final automobiles and therefore should have some combination of codes in both the PC and FG columns in Table 4.2. We then break up the "advanced top" into "simple-advanced top" and "complex-advanced top". "Simple-advanced top" refers to an advanced top country which exports its P&C to the "bottom" countries with a simply a one-way flow of P&C, while the "complex-advanced top" refers to an advanced top country which exports its P&C to the "middle" country wherein that middle country can at least re-export P&C to her.

Table 4.2: Codes for a "Top" Country

PC0100	FG0100
PC0110	FG0110
PC0010	FG0010
PC1100	

- a “middle” country is one that exports P&C to a top country, or it imports P&C from a top country, and either exports parts and components or exports final goods to other countries. This suggests that the country is internationally competitive in at least some part of the production process. We further break up “middle” into “simple middle” and “advanced middle”. Both “simple middle” and “advanced middle” countries import P&C from a top country and then either re-export the products to the top country or export them to other countries. The only difference between the two is that the “simple middle” country does not export final goods to any country, while the “advanced middle” does. To be a “simple middle”, a country must have at least one code in the first PC column and one code in the second PC column with the absence of any code(s) in the FG column in Table 3; while to be an “advanced middle”, a country must have at least one code in the first PC column and at least one code in the FG column in Table 4.3.

Table 4.3: Codes for Country a “Middle” Country

PC0001	PC0100	FG0100
PC1001	PC0110	FG0110
PC1000	PC0010	FG0010
PC0011		

- a “bottom” country is an importer with at least one of the codes in Table 4.4 and no exports of either P&C or final goods that are important to it or other countries (shown by the absence of any of the code(s) that appear in Table 4.2). We further consider such a country to be “bottom simple” if it only imports final goods (the country has only code(s) in the FG column), and

"bottom advanced" if it also imports P&C (codes in the PC column as well), as this suggests some domestic assembly.

Table 4.4: Codes for Country "Bottom"

PC0001	FG0001
PC1001	FG1001
PC1000	FG1000

4.5 Results and discussion

4.5.1 Country-level analysis

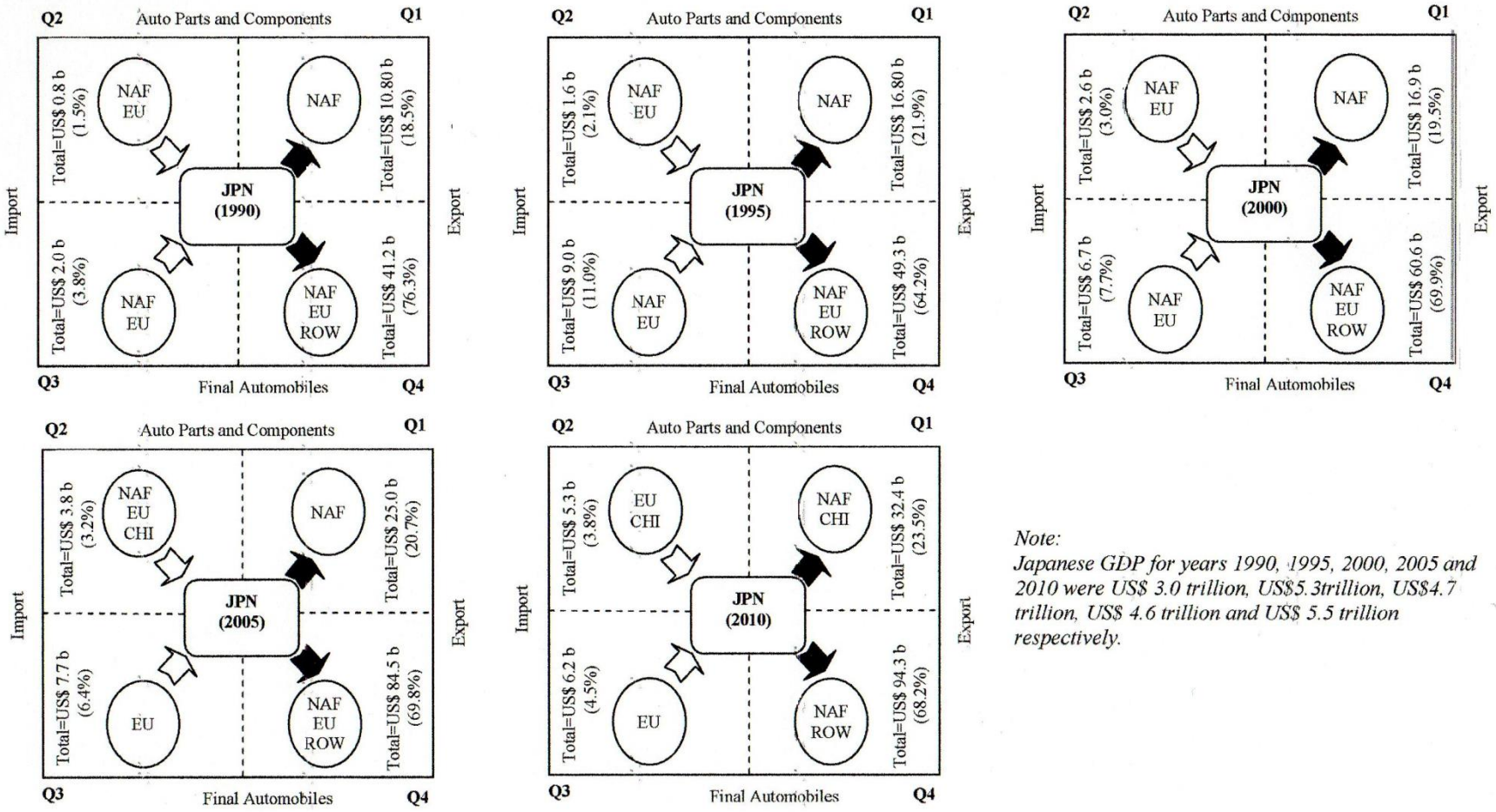
This analysis is carried out to determine the roles of each country in the automobile industry. Figures 4.2-4.10 illustrate East Asian countries' roles in P&C as well as final automobiles trade between 1990 and 2010. Based on Figure 4.2, Japan was consistently more of an exporter of both auto P&C and final automobiles than an importer. For example, in 2010, Japan exported about US$ 32.4 billion auto P&C worldwide, six times more than its imports of the same[34]. During the same period, the export value of final automobiles reached almost US$ 94.3 billion[35] (i.e., 15-fold greater than its imports). The important markets for Japanese auto P&C were NAFTA (1990, 1995, 2000, 2005 and 2010) and China (2010), with 30.0 percent going to NAFTA and 21.8 percent going to China in 2010. Meanwhile, the important markets for Japanese final automobiles in all those years were NAFTA, EU and the ROW. In 2010, 37.8 percent of Japanese final automobiles were exported to NAFTA, while 36.8 percent went to the ROW. As one of the world's leading suppliers of

[34]See Annex Table 4.1
[35]See Annex Table 4.2

automobiles, Japan has 11 vehicle firms, and nine of them (viz. Toyota, Daihatsu, Isuzu, Honda, Mitsubishi, Nissan, Mazda, Suzuki, and Fuji) produce passenger vehicles for both the local and foreign markets. These firms also have manufacturing operations in other countries and/or have joint-venture(s) with overseas firms (Polly, 2002). Meanwhile, trade barriers on foreign auto P&C and final automobiles imposed by the Japanese government remain an obstacle to foreign automobile firms (USTR, 2009).

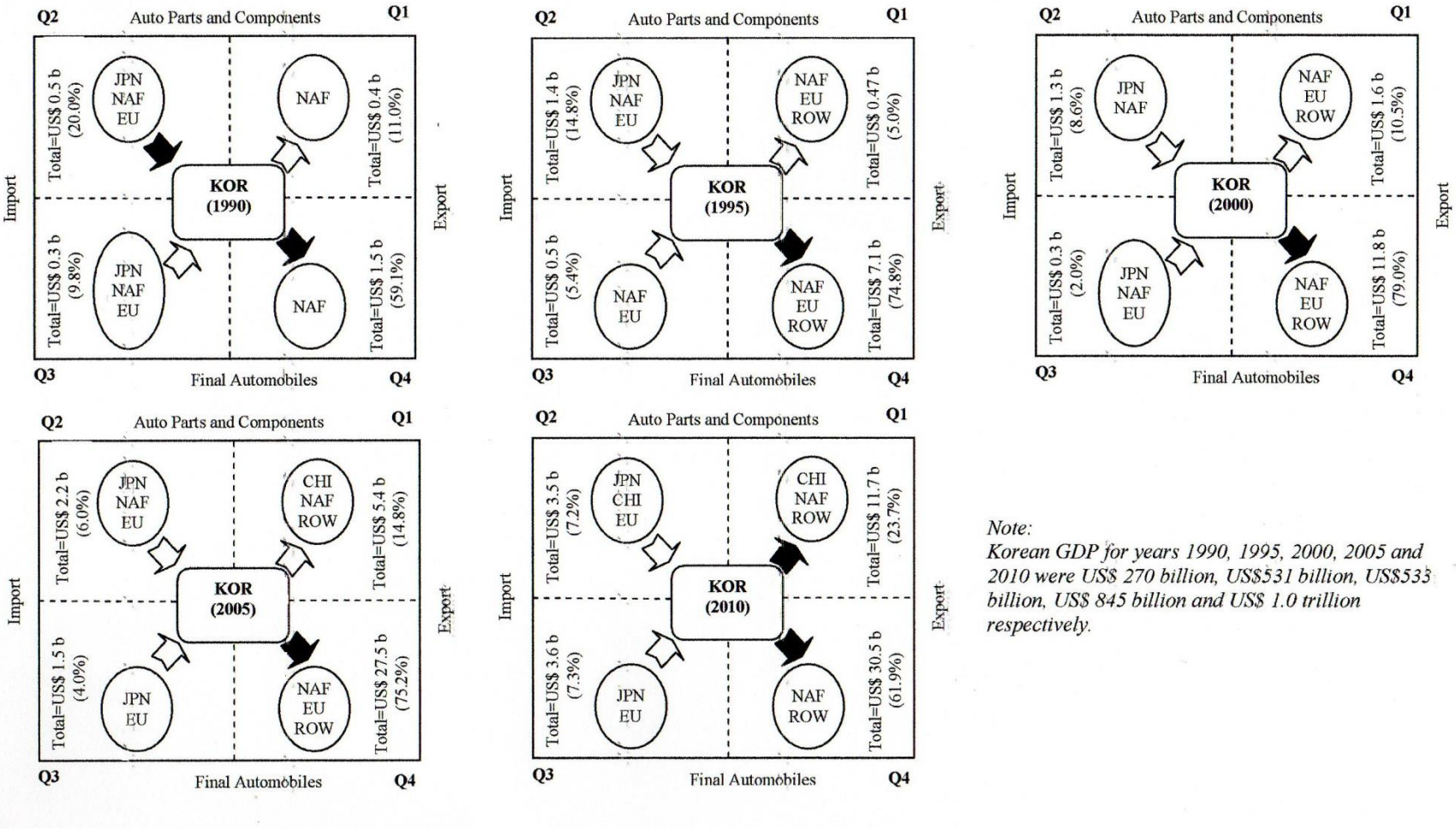
Figure 4.3 implies that the Republic of Korea was an important exporter of final automobiles in all years, which is consistent with its position as Asia's second largest final automobile exporter. The Korean government provides subsidised loan and tax incentives for automobile investments as well as export subsidies, including export promotion loans which enable Korean cars to be sold in foreign markets at less than half the domestic market price (Doner et al., 2004). Based on Figure 4.3, the important markets for its final automobiles were NAFTA, EU and ROW. In 2010, for example, Korean total export of final automobiles to the global market reached US$ 30.5 billion, while its imports only amounted to US$ 3.6 billion. In that year, more than 53 percent and 26.5 percent of its final automobiles went to the ROW and NAFTA, respectively. For auto P&C, Korea was not an important importer during 1995; however, by 2010 this had changed. For instance, in 2010, US$ 11.7 billion of auto P&C were exported and its major markets were ROW (35 percent), NAFTA (25.6 percent) and China (17.7 percent). Korea also has a large domestic market for final automobiles with annual sales of 1.5 million vehicles, which has been valuable to Korean producers (Doner et al., 2004).

Figure 4.2: Japanese Trade of Auto P&C and Final Automobiles



Note:
Japanese GDP for years 1990, 1995, 2000, 2005 and 2010 were US$ 3.0 trillion, US$5.3trillion, US$4.7 trillion, US$ 4.6 trillion and US$ 5.5 trillion respectively.

Figure 4.3: Korean Trade of Auto P&C and Final Automobiles

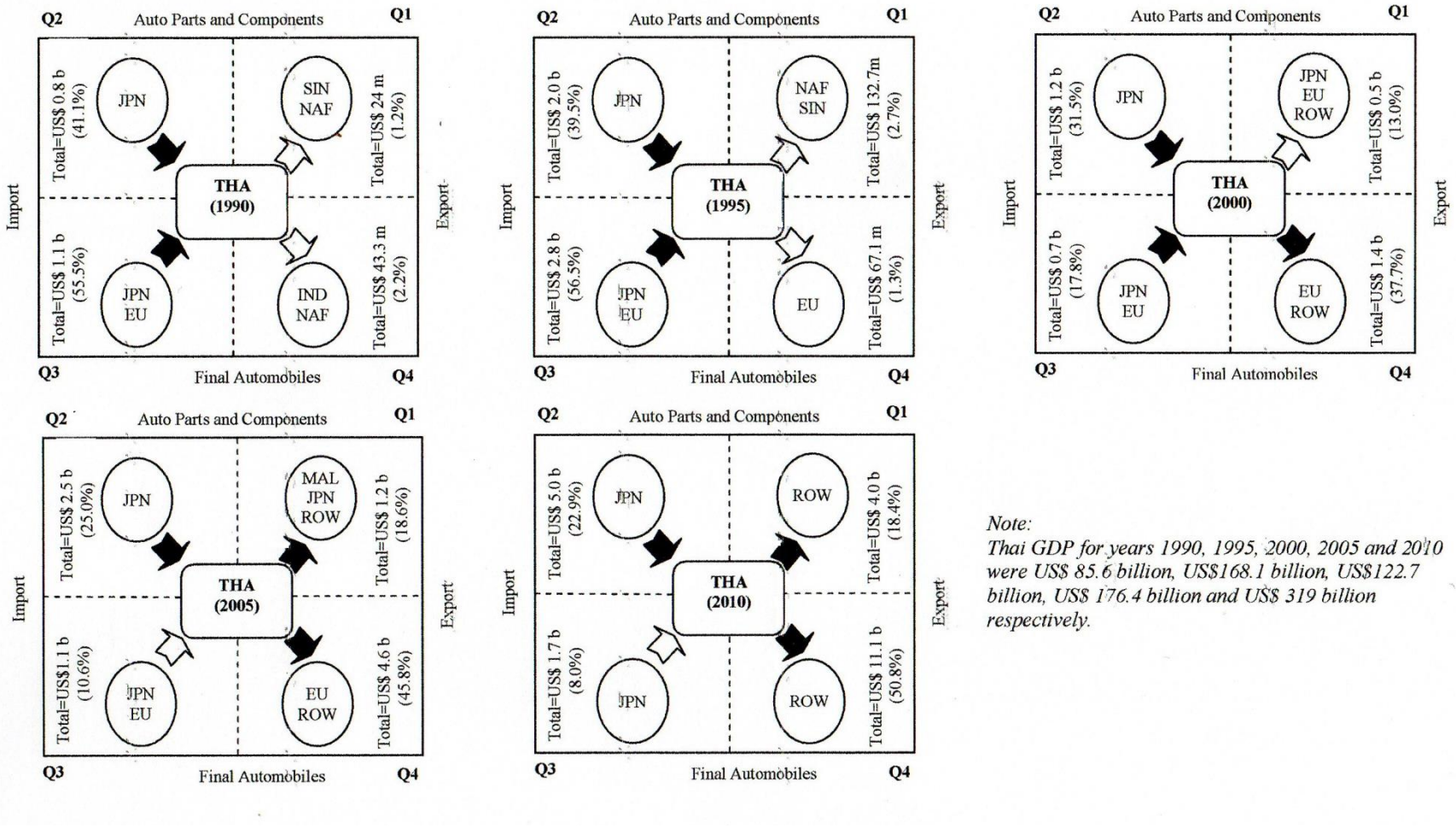


Note:
Korean GDP for years 1990, 1995, 2000, 2005 and 2010 were US$ 270 billion, US$531 billion, US$533 billion, US$ 845 billion and US$ 1.0 trillion respectively.

The Thai automobile industry has achieved mature world-class production, and is currently ranked 13th globally (Languepin, 2010). Based on Figure 4.4, we can see drastic changes in its role over a period of twenty years compared to other countries. In the 1990s, it was an important importer of auto parts, components and final automobiles, with Japan its major supplier, while the EU was also an important supplier of final automobiles. By 2000, Thailand had also become an important exporter of final automobiles with its major markets being the EU and ROW. By 2005, Thailand was no longer a major importer of final automobiles, but had become an important exporter of P&C. The major markets for Thai auto P&C were Japan, Malaysia, and ROW. In 2010, Thailand's export of final automobiles to foreign markets was US$ 11.1 billion (more than six times greater than its imports). Development in the Thai automobile industry was influenced by two decades of investment by Japanese OEMs, as well as government policies such as trade and investment liberalisation (summarised in Table 4.5)[36]. In addition to these policies, the Thai government also expanded infrastructure and investment incentives for industrial estates in the eastern seaboard area and improved port facilities for container vessels at Laem Chabang (Doner et al., 2004).

[36]See Fujita (1998) and Doner et al. (2004)

Figure 4.4: Thai Trade of Auto P&C and Final Automobiles



Note:
Thai GDP for years 1990, 1995, 2000, 2005 and 2010 were US$ 85.6 billion, US$168.1 billion, US$122.7 billion, US$ 176.4 billion and US$ 319 billion respectively.

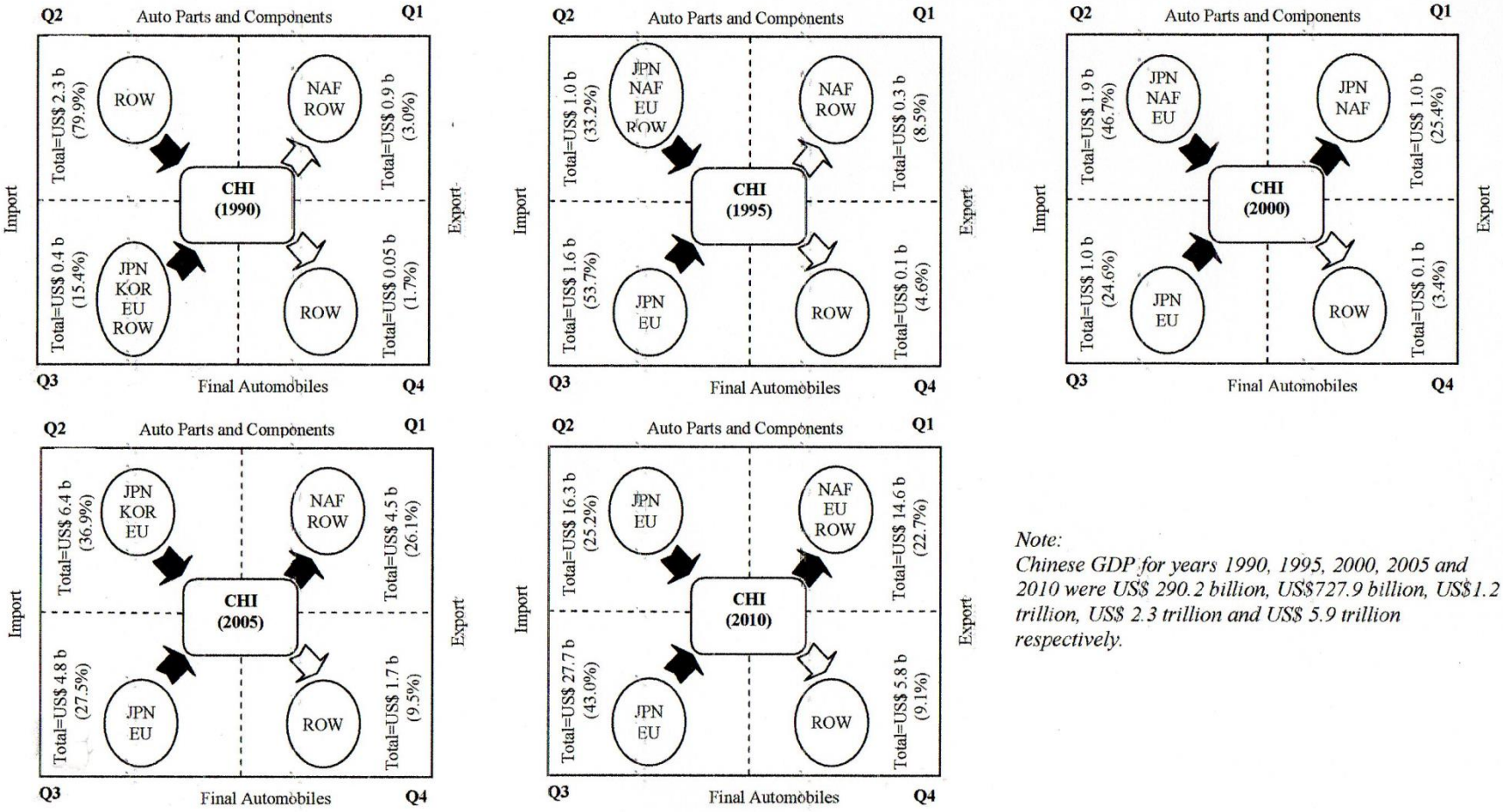
Table 4.5: Thailand's Trade and Investment Liberalisation Policies

Year	Policy
1991	• Lifting the ban on import of final passenger automobiles with a displacement volume of 2,300cc or less. • Reducing the total import tax on passenger cars and import duty rates on CKD kits.
1992	• Tariff reduction implemented on six important components and materials
1993	• Promoting "export orientation" for the automobile industry. • Giving incentives to assembling of final automobiles for export in the form of import duty exemption for automobile parts and corporate income tax exemption for eight years.
1994	• Giving permission for existing assemblers to increase capacity and models. • Giving permission for investments in new assembly plants and parts production.
2000	• Lifting of local content to comply with WTO regulations. • Ending of special decentralisation incentives to encourage clustering.

China has consistently been a major importer of both auto P&C and final automobiles (see Figure 4.5). The main suppliers of China's auto P&C were Japan, NAFTA, EU, and the Republic of Korea. Meanwhile, Japan and the EU were its important suppliers of final automobiles. Since 2000s, however, China's role has expanded to become an important exporter of auto P&C. The major market for these Chinese products were NAFTA (2000, 2005 and 2010), ROW (2005 and 2010), Japan (2000) and EU (2010). The change in China's role since 2000 coincides with certain newly implemented government policies. For example, through the Automotive Industry Policy 2004, the Chinese government encouraged research and development, production on a large scale for main P&C as well as global platforms, with an expectation that P&C would be built in China not only for the domestic market but also for export to foreign markets such as Japan, Europe, and North America (Holweg et al., 2005). Tariff reduction (as part of an agreement with the WTO) also encouraged growth in China's imports of auto P&C and final automobiles[37].

[37]The tariff for final automobiles dropped from 80% or 100% to 10%, while the tariff for final automobiles went down to 10% in 2006.

Figure 4.5: Chinese Trade of Auto P&C and Automobiles

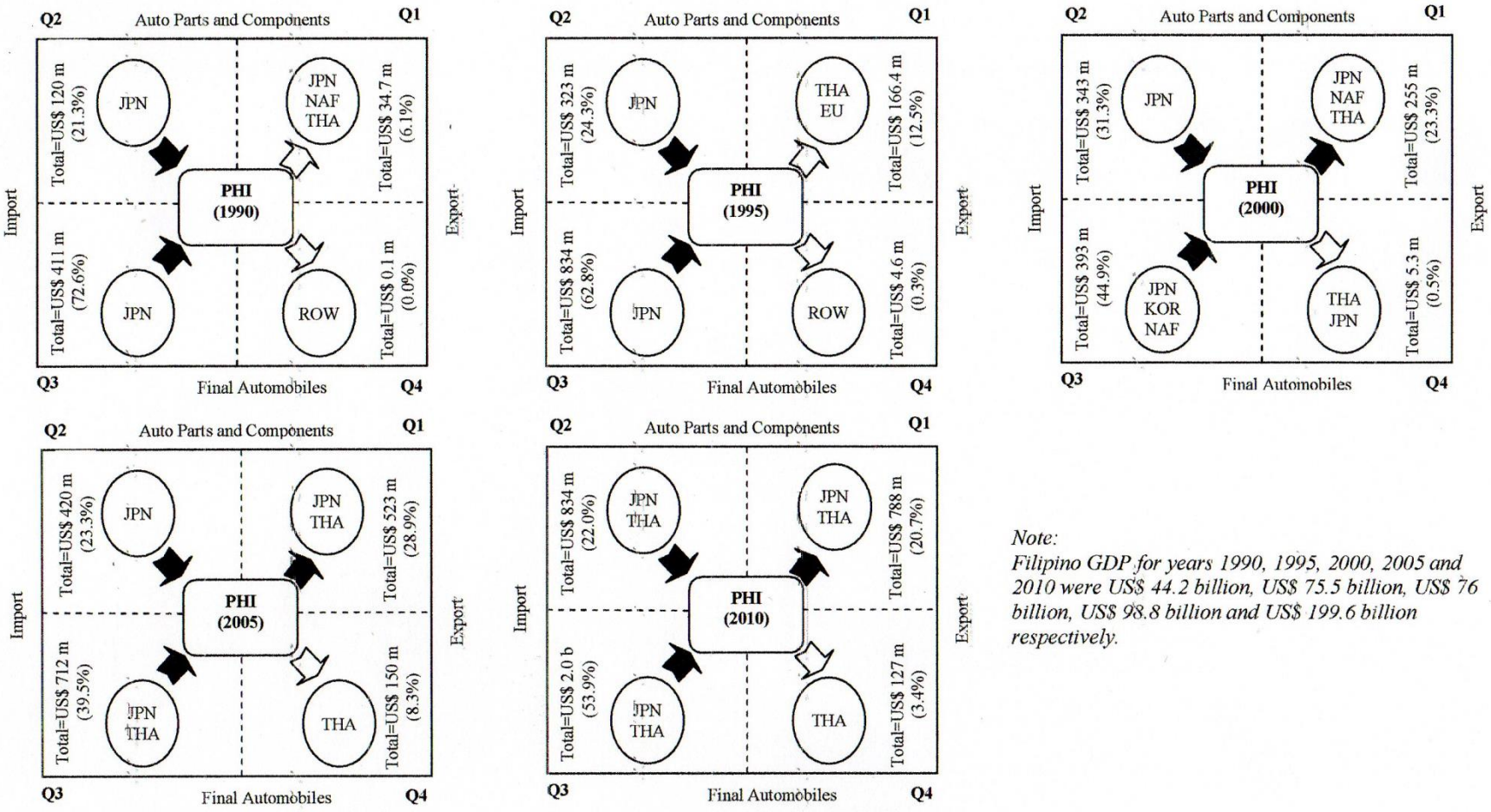


Note:
Chinese GDP for years 1990, 1995, 2000, 2005 and 2010 were US$ 290.2 billion, US$727.9 billion, US$1.2 trillion, US$ 2.3 trillion and US$ 5.9 trillion respectively.

Based on Figure 4.6, it is obvious that throughout the period under consideration, the Philippines was a major importer of auto P&C and final automobiles. Japan was the major supplier for both products. Thailand also became an important supplier of these products in 2010. As in the case of China, the Philippines became an important supplier of auto P&C since 2000, with the major markets for these being Japan and Thailand. As with China and the Philippines, Indonesia also became an important importer of auto parts, components and final automobiles (see Figure 4.7). Much of its auto P&C were imported from Japan and in 2010, Thailand also became one of its important suppliers. Both Japan and EU were the major suppliers of Indonesia's final automobiles. Since 2005, Thailand also became one of its important suppliers of final automobiles. The development of Indonesia's role as an important supplier of auto P&C was five years late compared to China and the Philippines. Indonesia's role had expanded to become an important exporter of auto P&C during 2005. The major market for these products were Japan (2005 and 2010), Malaysia (2005), Thailand (2010), and EU (2005). Both the Philippines and Indonesia supplied auto P&C to regional and global markets[38]. Tariff reduction under the framework of ASEAN Free Trade Area (AFTA) and ASEAN Industrial Cooperation (AICO) scheme may have contributed to the expansion of these countries' exports of auto P&C. Also, the introduction of a brand-to-brand complementation scheme, whereby P&C are supplied reciprocally within the ASEAN region as a way of maximising the benefits of mass production at the regional level, may have also raised the level of intra-regional trade in auto P&C.

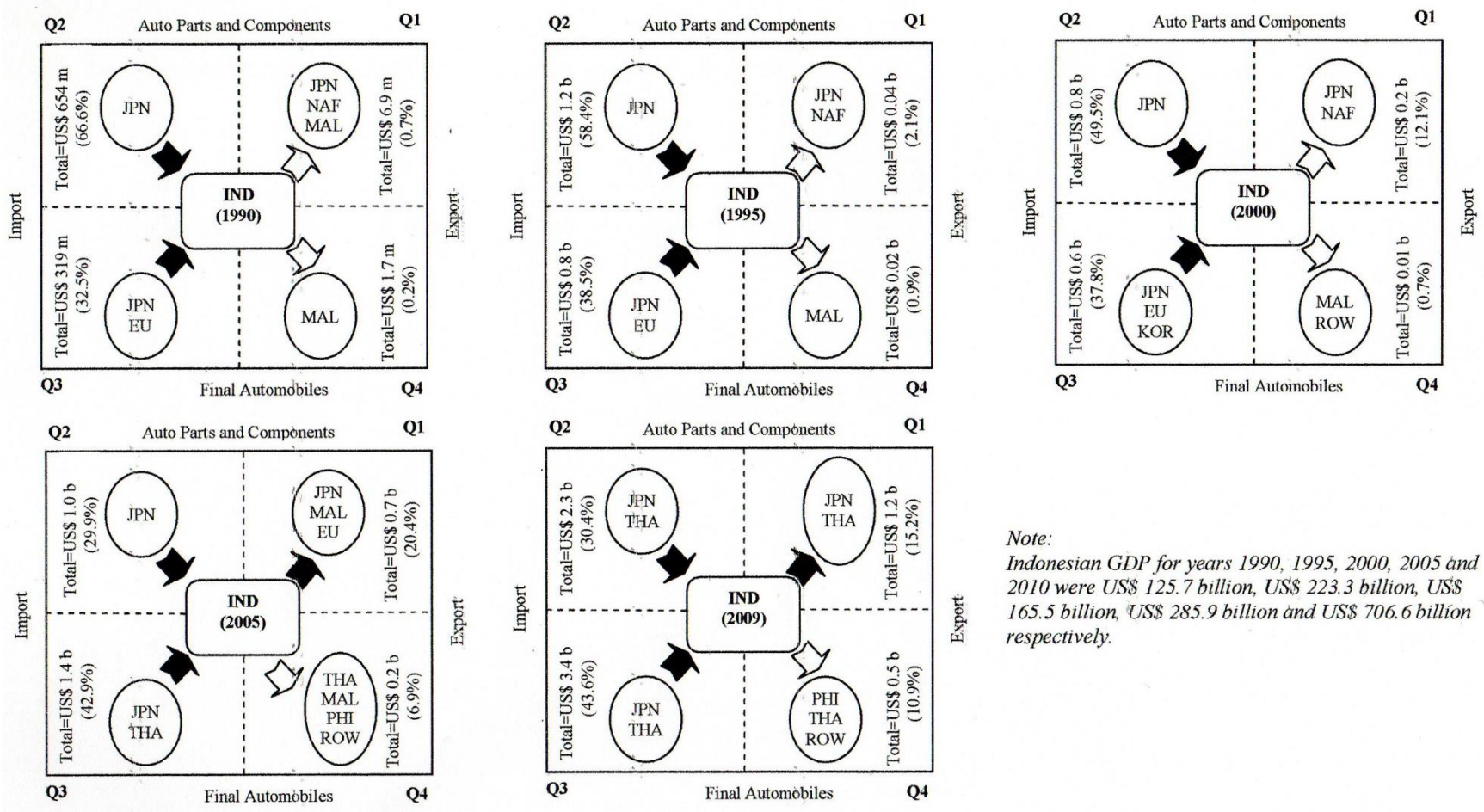
[38]According to Aldaba (2007), the Philippines' major exports in auto P&C were wiring harnesses (to Japan, the United States and Australia) and transmissions (to Thailand, Malaysia and Japan).

Figure 4.6: Filipino Trade of Auto P&C and Final Automobiles



Note:
Filipino GDP for years 1990, 1995, 2000, 2005 and 2010 were US$ 44.2 billion, US$ 75.5 billion, US$ 76 billion, US$ 98.8 billion and US$ 199.6 billion respectively.

Figure 4.7: Indonesian Trade of Auto P&C and Automobiles

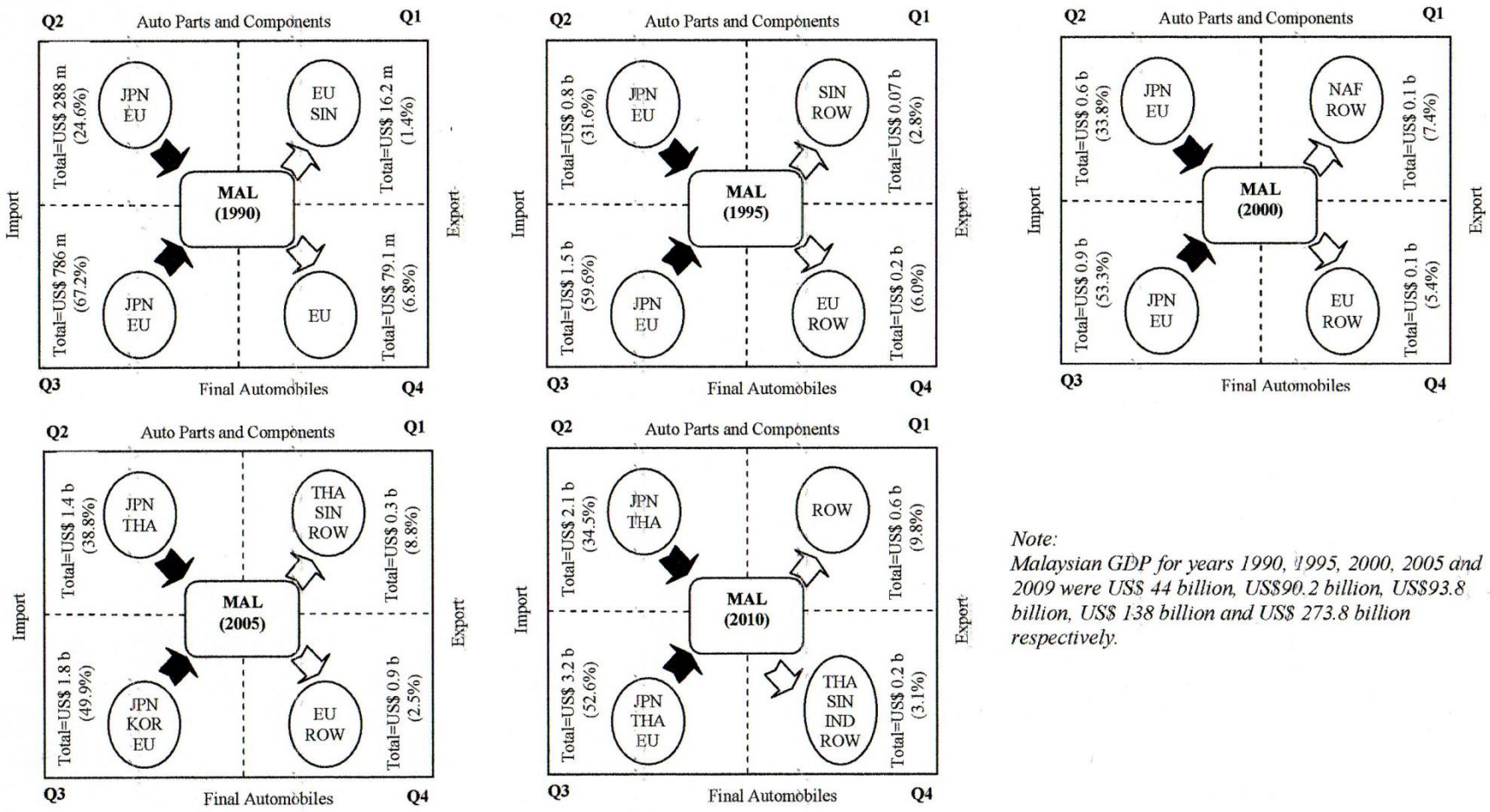


Note:
Indonesian GDP for years 1990, 1995, 2000, 2005 and 2010 were US$ 125.7 billion, US$ 223.3 billion, US$ 165.5 billion, US$ 285.9 billion and US$ 706.6 billion respectively.

The roles of Malaysia and Singapore in the automobile industry are similar and have remained unchanged over the twenty years under consideration (see Figures 4.8 and 4.9). Both countries were important importers of both auto P&C as well as final automobiles. Most of the Malaysian auto parts, components and final automobiles were imported from Japan and EU during 1990, 1995, and 2000. Since 2005, however, apart from Japan, Thailand has also become an important auto P&C supplier for Malaysia, while Korea (2005) and Thailand (2010) became important final automobile suppliers for Malaysia. Malaysia's exports of auto P&C were less prominent than its imports. In the case of Malaysia, the high import duty on non-national cars had increased domestic demand for national cars (e.g., Proton and Perodua)[39]. These two firms controlled more than 90 percent of all national vehicles sold annually (ESCAP, 2002)[40]. The high domestic demand for national cars indirectly increased demand for the imports of auto P&C[41]. In the case of Singapore, the important suppliers of auto parts, components and final automobiles were Japan and EU. Singapore seemed more inclined to engage in auto P&C production for each year between 1990 and 2010. In terms of final automobiles, Singapore was only active in importing rather than exporting. In 2010, Singapore imported about US$ 1.7 billion final automobiles from around the world, and most of the products were imported from the EU (47.2 percent) and Japan (21.3 percent). In addition, our results indicate that neither Malaysia nor Singapore is an important exporter of auto P&C or final automobiles.

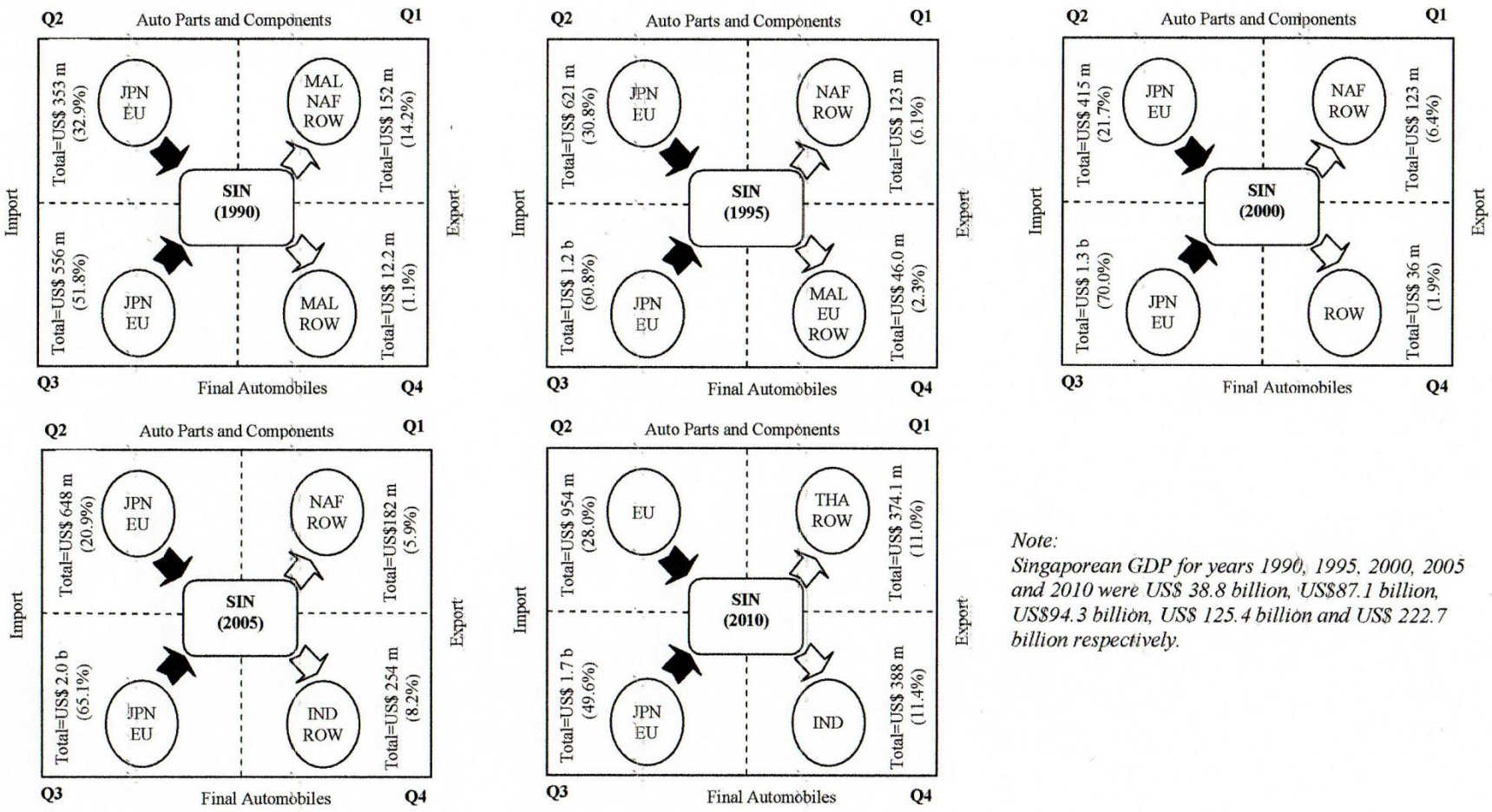
[39]Some of the vehicle prices increased by up to 300 percent due to the high import and excise duty (Mahidin and Kanageswary, 2004).
[40]Both Proton and Perodua produce cars for the domestic market and only 10 percent are exported.
[41]Manufacturers of local components still import intermediate inputs and automobile child parts for local production and value-added activities.

Figure 4.8: Malaysian Trade of Auto P&C and Automobiles



Note:
Malaysian GDP for years 1990, 1995, 2000, 2005 and 2009 were US$ 44 billion, US$90.2 billion, US$93.8 billion, US$ 138 billion and US$ 273.8 billion respectively.

Figure 4.9: Singaporean Trade of Auto P&C and Automobiles

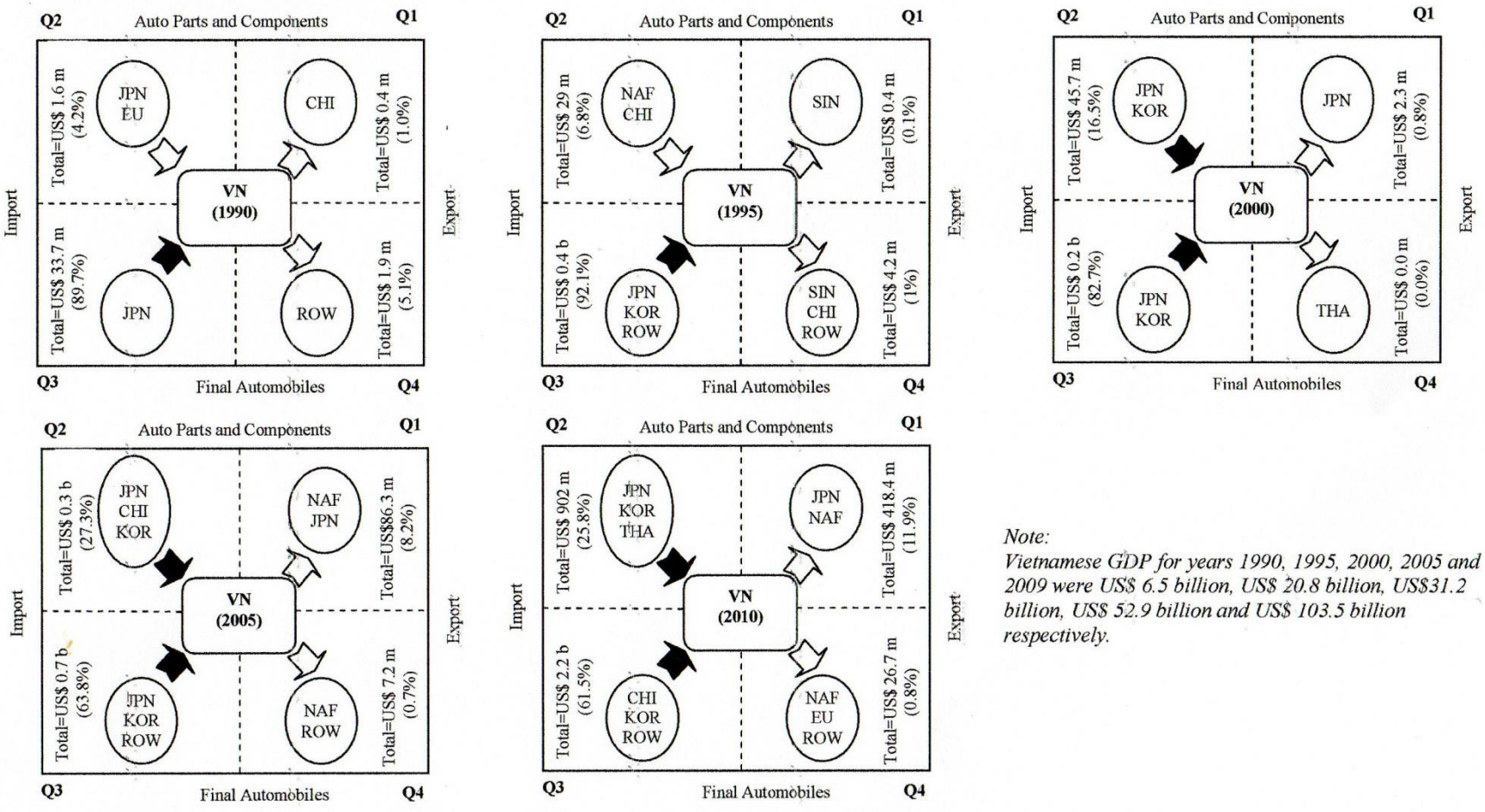


Note:
Singaporean GDP for years 1990, 1995, 2000, 2005 and 2010 were US$ 38.8 billion, US$87.1 billion, US$94.3 billion, US$ 125.4 billion and US$ 222.7 billion respectively.

The Vietnamese automobile industry is still in its early stage of development. Until the early 1990s, most of the vehicles in Vietnam were imported from the former USSR and other Eastern-bloc countries, while some of the vehicles were produced by the Vietnamese government (PricewaterhouseCoopers LLP, 2007). In the 1990s, the Vietnamese automobile industry began to grow when its government switched to an open-door policy and started looking for direct investments from the other countries. Based on Figure 4.10, Vietnam became an important importer of final automobiles in each year and most of these products were imported from Japan, the Republic of Korea and ROW. In 2010, however, China became an important supplier of Vietnamese final automobiles. And since 2005, Vietnam has become an important importer of auto P&C. The important suppliers of Vietnamese auto P&C were Japan, the Republic of Korea, China and Thailand. In 2010, for instance, Vietnam imported about US$ 902.7 million of auto P&C from around the world, with the major suppliers being the Republic of Korea (24.8 percent), Thailand (17.4 percent), and Japan (15.1 percent). Although the complete knock-down (CKD) assembly has begun to operate in Vietnam (with Mitsubishi, Toyota and Isuzu becoming some of the first global OEMs to operate in Vietnam) (PricewaterhouseCoopers, 2007), the growth of the Vietnamese auto P&C seemed to be somewhat slow compared to other ASEAN countries. In addition, according to Thuy (2008), the numbers of auto P&C companies in Vietnam are too small to provide P&C for assembly activities[42]. Because of this problem, assemblers in Vietnam still require imported auto P&C for CKD kits to enable them to operate.

[42]Local auto parts companies are able to produce only around 36 to 42 percent P&C for assemblers to build cars (Thuy, 2008).

Figure 4.10: Vietnamese Trade of Auto P&C and Final Automobiles



Note:
Vietnamese GDP for years 1990, 1995, 2000, 2005 and 2009 were US$ 6.5 billion, US$ 20.8 billion, US$31.2 billion, US$ 52.9 billion and US$ 103.5 billion respectively.

4.5.2 Network-level analysis

In this twenty-first century, East Asia is now recognised as a prospective growth region for the automobile industry, with potential to be the world's largest automobile market given its huge population. The automobile markets in developed countries, however, have reached maturity and have almost no growth potential. This section examines the position of each country in the international production chain within the automobile industry in East Asian countries as well as its development during the years 1990, 1995, 2000, 2005, and 2010. Table 4.6 outlines the major trade links for each country/region, while a visual representation of these links is illustrated in Figure 4.11. The following analysis highlights the important role played by Japanese automobile firms in the development of the East Asian region. It has been estimated elsewhere that about 90 percent of all domestic vehicle production in this region is through cooperation with Japanese firms and inevitably through transfer of Japanese technology (Shimokawa, 2010).

The domination of Japan in East Asia's automobile industry has resulted in many countries in this region relying heavily on her for both final automobiles and auto P&C. However, in this dominance-dependence relationship the position of dominant country (e.g. Japan) is influenced by the position of its subordinate(s) and vice-versa. As we can see in Table 4.6, in 1990 Japan's position was categorised as a "complex-advanced top". This classification is given to Japan because in that particular year one of its subordinates (i.e., Republic of Korea) was still an "advanced middle" country. However, five years later, Japan's position changed to "simple-advanced top" when the position of the Republic of Korea developed from "advanced middle" to "simple top" country and no longer significantly relied on Japan or western countries for its auto P&C.

By 2000, Japan's position had again developed into a "complex-advanced top" following the development of its links with the automobile industry in Southeast Asia (notably Thailand and the Philippines) and China (see Table 4.6). Like most other countries in the East Asian region, in the 1990s Thailand, the Philippines and China were initially categorised as "advanced bottom" because they only served as important importers of auto parts, components and final automobiles. Nonetheless, by 2000, both the Philippines and China had improved their position to "basic middle" since they managed to become both important importers and exporters of auto P&C. These two countries have become the assembling centre of P&C in that they import "child parts"[43] from developed countries, particularly Japan and EU, and then export these products to other countries. Some of these products were also re-exported to Japan. The situation in Thailand is somewhat different from these two countries. Since 2000, Thailand imported auto P&C from Japan (e.g. engines) and the Philippines (e.g. transmissions), and then assembled them with local auto P&C (e.g. body panel) to become completed automobiles, which were then exported to ROW and EU. In this respect, Thailand seems to be more competitive, particularly in the final assembly activities and is thus located at the advance stage, namely, as an "advanced middle" country.

Based on Table 4.6, Malaysia and Singapore are dominant importer countries of auto parts, components and final automobiles (with codes PC0001 and FG 0001), thus "advanced bottom" countries. Even though they relied on Japan for their auto P&C as well as final automobiles, the changes in the Japanese position between 1990 and 2010 did not seem to influence their position. As in the case of Malaysia and Singapore, Indonesia also relied on Japan for its auto parts, components and final

[43] "Child parts" refer to the small parts needed to produce a complete P&C.

automobiles, and is thus categorised as an “advanced bottom” country. However, the role played by Japan had successfully expanded Indonesia’s components industry (Johnson and Rachman, 2008). Hence, by 2005 Indonesia had become an important exporter of auto P&C and its position had developed from the “advanced bottom” to the “basic middle”. Unfortunately, Indonesia failed to maintain this position due to the reduction in demand for products such as motor vehicle parts, motorcycle parts, gearbox and tyres following the 2007-2012 global financial crises (Wulandari, 2009).

According to Table 4.6, the Republic of Korea experienced rapid development in its automobile industry as its position changed every five years compared to other countries between 1990 and 2010. In 1990, the Republic of Korea was an “advanced middle” country as the country imported auto P&C and exported final automobiles. The Korean auto P&C industry grew in such a way that from 1995 it no longer depended on imported auto P&C from the “top” countries. In the 2000s, Korean automakers aggressively sorted out their overseas production bases (Jung, 2007). At that time, Korea’s exports of auto P&C became important. These developments have spurred the improvement in its position from “basic top” to “simple-advanced top”. As a “basic top”, its exports of final automobiles were important as in 1995, with its major export destinations being Vietnam, NAFTA, EU and ROW. Meanwhile, as a “simple-advanced top”, its exports of both final automobiles and auto P&C had become important by 2000. For its exports of auto P&C, only Vietnam became an important market destination and this country relied on Korea as its major supplier, but not vice-versa (PC0100). Table 4.6 also indicates that Vietnam improved its position from “basic bottom” to “advanced bottom” in 2000 as it started to import auto P&C from the Republic of Korea for domestic assembly. In terms of its exports of final automobiles, NAFTA and China were its important export destinations. Over

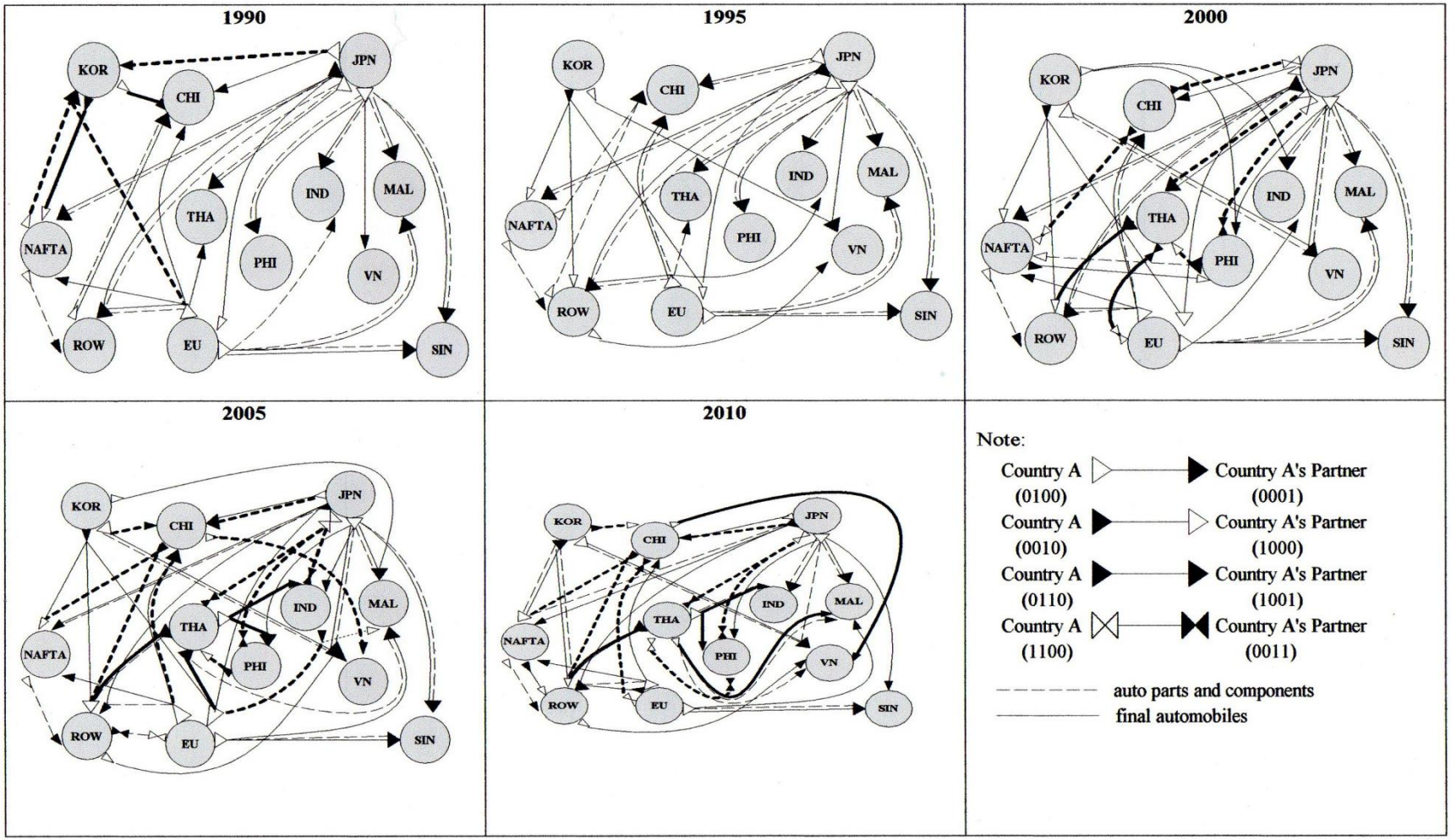
the next five years, the Republic of Korea again improved its position from “simple-advanced top” in 2000 to “complex-advanced top” in 2005. This was due to the export of auto P&C from the Republic of Korea to not only Vietnam but also China (i.e., a “basic middle” country). By 2010, China had become an important market for Korean auto P&C, along with NAFTA and ROW.

Table 4.6: Countries' Position in the IPNs

Country	Country's codes				
	1990	**1995**	**2000**	**2005**	**2010**
Japan	PC0100(K,T,P,I,M,S) FG0100(C,T,P,I,M,S,V) PC0110(N) FG0110(N) FG0010(E)	PC0100(C,T,P,I,M,S) FG0100(C,T,P,I,M,S,V) PC0110(N) FG0110(N) FG0010(E)	PC0100(T,I,M,S,V,R) FG0100(C,T,P,I,M,S,V) PC0110(N) FG0110(N,R) FG0010(E) PC1100(C,P)	PC0100(C,M,S,V) FG0100(C,P,I,M,S,V) PC0110(N) FG0110(N,R) FG0010(E) PC1100(T,P,I)	PC0100(I,M,V,R) FG0100 (C,P,I,M,S) PC0110 (C) FG0110 (N) PC1100 (T,P) PC0010 (N)
	Simple-advanced top		**Complex-advanced top**		
Thailand	PC0001(J) FG0001(J,E)	PC0001(J,E) FG0001(J)	PC0001(J) FG0010(R) FG0001(J) FG0011(E) PC1000(P)	PC0011(J) FG0100(I,P) PC1000(P) FG0010(E,R)	PC0011(J) FG0010(R) PC1100(P) FG0100(M,P,I) PC0100(M,V)
	Advanced bottom		**Advanced middle**		
The Philippines	PC0001(J) FG0001(J)	PC0001(J) FG0001(J)	PC0010(T,N) FG0001(J,K) PC0011(J) FG0001(N)	PC0010(T) FG0001(J,T) PC0011(J)	PC0011(J,T) FG0001(J,T)
	Advanced bottom		**Basic middle**		
Indonesia	PC0001(J) FG0001(J,E)	PC0001(J) FG0001(J,E)	PC0001(J) FG0001(J,E,K)	PC0010(M,E) FG0001(J,T) PC0011(J)	PC0001(J) FG0001(J,T)
	Advanced bottom		**Basic middle**		**Advanced bottom**
China	PC0001(R) FG0001(J,E,K,R)	PC0001(J,E,R,N) FG0001(J,E,N)	PC0001(E) FG0001(J,E) PC0011(J,N)	PC0001(J,E,U.K) FG0001(J,E) PC0010(R,N)	PC1001(J) PC1000(K) PC0011(E) FG0100(V) PC0010(N,R) FG0001(J,E)
	Advanced bottom		**Basic middle**		
The Republic of Korea	PC0001 (J,E,N) FG0100 (C) FG0010 (N)	FG0100 (V) FG0010 (N,E,R)	PC0100 (V) FG0100 (V,I,P) FG0010 (N,E,R)	PC0100 (V,C) FG0100 (V,M) FG0010 (N,E,R)	PC0100 (V) PC0010 (N,C,R) FG0100 (V) FG0010 (N,R)
	Advanced middle	**Basic top**	**Simple-advanced top**	**Complex-advanced top**	
Vietnam	FG0001(J)	FG0001(J,K)	PC0001(K) FG0001(J)	PC0001(J,K,C) FG0001(J,K,R)	PC0001(J,K,T) FG0001(K,R,C)
	Basic bottom		**Advanced bottom**		
Malaysia	PC0001(J,E) FG0001(J,E)	PC0001(J,E) FG0001(J,E)	PC0001(J,E) FG0001(J,E)	PC0001(J) PC1001(T) FG0001(J,E,K) PC1000(I)	PC0001(J,T) FG0001(J,T,E)
	Advanced bottom				
Singapore	PC0001(J,E) FG0001(J,E)	PC0001(J,E) FG0001(J,E)	PC0001(J,E) FG0001(J,E)	PC0001(J,E) FG0001(J,E)	PC0001(E) FG0001(J,E)
	Advanced bottom				

Note: In the parentheses is the country's trading partner(s), where J*=Japan; K=Republic of Korea; C=China; T=Thailand; I=Indonesia; P=the Philippines; M=Malaysia; S=Singapore; V=Vietnam; N=NAFTA; E=European Union; and R=Rest of the World.*

Figure 4.11: IPNs in Automobile Industry



4.6 Conclusion

The shift in production locations from developed to developing countries has led to a significant change in the automobile world. Many countries have put in efforts to further develop their automotive sector, and this has resulted in changes to their roles within the supply chain as well as the patterns of trade in the automobile industry. The results suggest that the role of Japan as a supplier of auto parts, components and final automobiles as well as those of Malaysia and Singapore had remained unchanged. On the other hand, the role of China, Indonesia and the Philippines has expanded from importers of auto P&C and final automobiles to importers of auto P&C and final automobiles in addition to being exporters of auto P&C. Nonetheless, the development of Indonesia's role of being exporter of auto P&C was somewhat late compared to China and the Philippines.

The role of Thailand has changed dramatically during the same period, from an importer of auto P&C and final automobiles in the 1990s to an importer of auto P&C and automobiles as well as being an exporter of auto P&C and final automobiles in the decade that followed. Interestingly, starting from 2005 Thailand was no longer an importer of final automobiles, probably because that country has started to produce Japanese cars for domestic use. Meanwhile, the role of the Republic of Korea has expanded from being an exporter of only final automobiles to being an exporter of auto P&C and final automobiles, while the role of Vietnam has also expanded from being an importer of only final automobiles to an importer of auto P&C and final automobiles.

The results also indicate that Japan became the major trading partner for most countries under study and it played an important role in supplying auto P&C and final automobiles to most East Asian countries even though its major markets for these products were the United States and ROW. Apart from Japan, the Republic of Korea and Thailand became the main partners of many countries, particularly in Southeast Asia, as those countries depended on them as sources of auto P&C and final automobiles.

As mentioned earlier, the pattern of trade networks that are categorised as “top”, “middle” and “bottom” have been generated from countries’ role(s) as an exporter and importer of auto P&C and final automobile as well as their relationship with partner(s). As expected, the results show that between 1990 and 2010 the “top” position in East Asia’s production networks has consistently been occupied by Japan. That position has also been consistently occupied by the Republic of Korea after 1995. Specifically, the Republic of Korea has improved its position from “advanced-middle” to “basic top” in 1995 and consequently achieved the same position as Japan (i.e., “complex-advanced top”) in 2005. Meanwhile, rapid development in the automobile industry of Thailand, China and the Philippines has led to those countries improving their position from “bottom” to “middle” after 2000, with Thailand moving ahead of both China and the Philippines to become an “advanced-middle” country. Between 1990 and 2010, the “bottom” position has consistently been occupied by Malaysia, Singapore and Vietnam between. In the case of Indonesia, however, its position is somewhat inconsistent throughout the years under study.

The results also indicate that Japan has played a major role in the transformation of the auto industry in East Asia, for it is now importing auto P&C from its East Asian

partners as well as exporting auto P&C to Thailand which then exports them as final automobiles. In addition, through rapid development of its automobile industry, the Republic of Korea has emerged as another important player in East Asia's automobile industry after Japan, and now plays a pivotal role in stimulating the development of the automobile industry in both Vietnam and China. This study also allows one to conclude that development in Japan's and Korea's status within the international automobile production network has been influenced by development in their subordinates' automobile industry and vice versa. In addition, the results also suggested that for some countries, there was in general a trend towards exporting P&C for domestic assembly for the local market.

Annex to Chapter 4

Annex Figure 4.1: Sensitivity Analysis

Country	Year	1st Quadrant (P&C Exporter)	2nd Quadrant (P&C Importer)	3rd Quadrant (FG Importer)	4th Quadrant (FG Exporter)
JAPAN (12%)	1990	NAF			NAF, EU, ROW
	1995	NAF, ROW			
	2000	NAF, EU, ROW			
	2005				
	2010	NAF, ROW, CHI			
JAPAN (15%)	1990	NAF			NAF, EU, ROW
	1995				
	2000				
	2005				
	2010	NAF, CHI			NAF, ROW
JAPAN (18%)	1990	NAF			NAF, EU, ROW
	1995				
	2000				NAF, ROW
	2005				
	2009	NAF, CHI			
KOREA (12%)	1990		JPN, NAF, EU		NAF
	1995				NAF, EU, ROW
	2000				
	2005	CHI, NAF, ROW			
	2010	CHI, NAF, EU, ROW			NAF, ROW
KOREA (15%)	1990		JPN, NAF, EU		NAF
	1995				NAF, EU, ROW
	2000				
	2005				
	2010	CHI, NAF, ROW			NAF, ROW
KOREA (18%)	1990		JPN, NAF		NAF
	1995				NAF, EU, ROW
	2000				
	2005				
	2010	NAF, ROW			NAF, ROW
CHINA (12%)	1990		ROW	JPN,KOR, EU, ROW	
	1995		JPN, NAF, EU, ROW	JPN, EU	
	2000	JPN, NAF, EU, ROW	JPN, NAF, EU		
	2005		JPN, KOR, EU		
	2010			JPN, NAF, EU	
CHINA (15%)	1990		ROW	JPN, KOR, EU, ROW	
	1995		JPN, NAF, EU, ROW	JPN, EU	
	2000	JPN, NAF	JPN, NAF, EU		
	2005	NAF, ROW	JPN, KOR, EU		
	2010	NAF, EU, ROW	JPN, EU		
CHINA (18%)	1990		ROW		
	1995		JPN, ROW	JPN, EU	
	2000	JPN, NAF	JPN, NAF, EU		

Country	Year	1st Quadrant (P&C Exporter)	2nd Quadrant (P&C Importer)	3rd Quadrant (FG Importer)	4th Quadrant (FG Exporter)
	2005	NAF	JPN, KOR, EU		
	2010	NAF, ROW	JPN, EU		
THAILAND (12%)	1990		JPN	JPN, EU	
	1995				
	2000	JPN, NAF, EU ROW	JPN, EU		EU, ROW
	2005	JPN, MAL, ROW	JPN		
	2010	JPN, MAL, ROW, IND			ROW
THAILAND (15%)	1990		JPN	JPN, EU	
	1995				
	2000				EU, ROW
	2005	JPN, MAL, ROW			
	2010	ROW			ROW
THAILAND (18%)	1990		JPN	JPN, EU	
	1995				
	2000				EU, ROW
	2005	MAL, ROW			
	2010	ROW			ROW
INDONESIA (12%)	1990		JPN	JPN, EU	
	1995				
	2000	JPN, MAL, PHI, NAF		JPN, KOR, EU	
	2005	JPN, MAL, EU	JPN, THA	JPN, THA	
	2010	JPN, MAL, THA,ROW			THA, PHI, ROW
INDONESIA (15%)	1990		JPN	JPN, EU	
	1995				
	2000			JPN, EU, KOR	
	2005	JPN, MAL, EU		JPN, THA	
	2010	JPN, THA	JPN, THA		
INDONESIA (18%)	1990		JPN	JPN, EU	
	1995				
	2000			JPN, KOR	
	2005	JPN, MAL		JPN, THA	
	2010	JPN, THA	JPN, THA		
THE PHILIPPINES (12%)	1990		JPN, NAF, EU	JPN	
	1995	JPN, THA, EU	JPN		
	2000	JPN, THA, NAF		JPN, KOR, NAF	
	2005	JPN, THA		JPN, THA	
	2009		JPN, THA		
THE PHILIPPINES (15%)	1990		JPN	JPN	
	1995				
	2000	JPN, NAF, THA		JPN, KOR, NAF	
	2005	JPN, THA		JPN,THA	
	2010		JPN,THA		
THE PHILIPPINES (18%)	1990		JPN	JPN	
	1995				
	2000	JPN, THA			
	2005			JPN, THA	
	2010		JPN, THA		

Country	Year	1st Quadrant (P&C Exporter)	2nd Quadrant (P&C Importer)	3rd Quadrant (FG Importer)	4th Quadrant (FG Exporter)
MALAYSIA (12%)	1990		JPN, SIN, EU	JPN, EU	
	1995		JPN, EU		
	2000				
	2005		JPN, THA	JPN, KOR, EU	
	2010			JPN, THA, EU	
MALAYSIA (15%)	1990		JPN, EU	JPN, EU	
	1995				
	2000				
	2005		JPN,THA	JPN, KOR, EU	
	2010			JPN, THA, EU	
MALAYSIA (18%)	1990		JPN, EU	JPN, EU	
	1995		JPN		
	2000				
	2005		JPN, THA	JPN, KOR	
	2010			JPN, THA	
SINGAPORE (12%)	1990	MAL, NAF, ROW	JPN, NAF, EU	JPN, EU	
	1995				
	2000		JPN, EU		
	2005				
	2010		JPN, NAF, EU		
SINGAPORE (15%)	1990		JPN, EU	JPN, EU	
	1995				
	2000				
	2005				
	2010		EU		
SINGAPORE (18%)	1990		JPN, EU	JPN, EU	
	1995				
	2000				
	2005		EU		
	2010				
VIETNAM (12%)	1990			JPN, EU	
	1995			JPN, KOR, ROW	
	2000		JPN, KOR, EU	JPN, KOR	
	2005		CHI, JPN,KOR, THA, EU	JPN, KOR, ROW	
	2010		CHI, JPN, KOR, THA, EU	CHI, NAF, KOR, ROW	
VIETNAM (15%)	1990			JPN	
	1995			JPN, KOR, ROW	
	2000		JPN, KOR	JPN,KOR	
	2005		JPN, KOR, CHI	JPN, KOR, ROW	
	2010		JPN, KOR, THA	CHI, KOR, ROW	
VIETNAM (18%)	1990			JPN	
	1995			JPN, KOR,ROW	

Country	Year	1st Quadrant (P&C Exporter)	2nd Quadrant (P&C Importer)	3rd Quadrant (FG Importer)	4th Quadrant (FG Exporter)
	2000			JPN, KOR	
	2005		JPN,KOR		
	2010		KOR	KOR, ROW	

Notes: (1) CHI=China; IND=Indonesia; JPN=Japan; KOR=Republic of Korea; MAL=Malaysia; PHI=the Philippines; SIN=Singapore; VN=Vietnam; THA=Thailand; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

(2) The shaded areas indicate the important quadrants..

Annex Table 4.1: Trades of Automobile P&C in East Asia (US$ million)

(a) Year 1990

	EXPORTER												
IMPORTER	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN	NAF	EU	ROW	TOTAL
	JPN		29.9	3.0	2.1	2.8	9.3	2.0	0.3	-	543.6	406.5	41.7	1041.3
	KOR	333.2		1.5	-	-	-	-	0.1	-	142.3	91.7	2.4	571.2
	CHI	53.2	8.7		0.1	-	-	-	9.4	0.3	15.4	212.6	2211.0	2510.6
	THA	732.3	1.0	3.0		0.4	8.2	0.7	0.7	-	19.9	99.7	2.6	868.4
	IND	626.7	0.8	0.4	0.3		0.0	0.3	-	0.0	4.0	21.0	19.0	672.5
	PHI	85.8	1.6	0.0	0.2	-		0.2	7.5	-	17.3	16.8	2.8	132.4
	MAL	186.0	1.9	0.2	1.0	2.4	0.0		50.2	-	3.8	87.3	14.5	347.3
	SIN	153.2	6.9	4.4	6.0	-	0.1	6.0		-	68.5	204.5	21.9	471.5
	VN	0.6	-	-	0.0	0.0	-	-	-			0.9	0.0	1.6
	NAF	6120.9	195.6	20.9	10.4	1.3	15.8	3.1	24.8	-	17719.1	2992.4	526.3	27630.6
	EU	919.0	15.7	3.7	2.7	0.1	0.8	9.6	5.8	-	986.4	23748.3	642.8	26334.9
	ROW	983.8	26.4	51.0	3.4	0.1	0.4	2.6	53.1	0.0	1100.2	3493.2	379.6	6094.1
	TOTAL	10194.7	288.5	88.1	26.2	7.0	34.7	24.5	152.0	0.4	20620.4	31375.0	3864.8	66676.3

Note: JPN=Japan; KOR=The Republic of Korea; CHI=China; THA=Thailand; IND=Indonesia; PHI=the Philippines; MAL=Malaysia; SIN=Singapore; VN=Vietnam; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

(b) Year 1995

	EXPORTER												
IMPORTER	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN	NAF	EU	ROW	TOTAL
	JPN		44.4	37.1	11.4	9.0	21.9	5.5	0.7	-	852.4	597.4	64.0	1643.9
	KOR	658.4		1.4	0.1	0.7	0.1	0.1	0.1	-	478.1	252.4	10.7	1402.2
	CHI	263.3	19.6		4.0	0.0	0.0	0.0	4.8	-	161.1	152.8	388.4	994.2
	THA	1775.4	3.7	3.2		2.7	56.8	9.5	0.7	-	17.1	101.9	3.1	1974.0
	IND	1079.1	4.3	2.8	3.2		13.5	2.6	-	-	43.3	39.2	30.8	1218.9
	PHI	258.3	10.4	1.0	3.1	0.0		4.7	4.3	-	19.7	14.1	7.6	323.2
	MAL	580.7	5.6	0.6	19.3	3.6	4.2		1.2	0.0	35.1	128.3	23.0	801.6
	SIN	193.1	19.8	7.8	27.7	-	0.2	22.0		0.4	92.2	220.2	37.7	621.1
	VN	0.7	2.3	9.2	2.0	0.1	1.4	0.1	3.3		7.4	1.6	1.1	29.2
	NAF	7892.2	138.5	138.5	28.6	21.8	12.6	8.3	24.7	-	25290.0	3539.7	817.8	37912.7
	EU	1999.6	74.4	11.5	15.5	1.8	53.5	4.4	5.3	-	2725.3	34276.8	1086.9	40254.8
	ROW	2101.8	146.2	50.4	17.9	5.0	2.1	12.7	77.9	0.0	2392.7	4841.0	1477.9	11125.5
	TOTAL	16802.7	469.3	263.4	132.7	44.7	166.4	70.0	123.0	0.4	32114.4	44165.5	3949.0	

Note: JPN=Japan; KOR=The Republic of Korea; CHI=China; THA=Thailand; IND=Indonesia; PHI=the Philippines; MAL=Malaysia; SIN=Singapore; VN=Vietnam; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

(c) Year 2000

	EXPORTER												
IMPORTER	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN	NAF	EU	ROW	TOTAL
	JPN		99.5	207.4	128.9	52.3	78.3	13.3	1.2	2.2	1403.5	558.4	39.3	2584.2
	KOR	563.4		21.2	0.5	1.1	0.2	0.3	0.7	0.0	427.3	191.6	80.6	1286.8
	CHI	537.9	40.6		3.7	1.1	0.0	3.6	0.3	-	412.2	887.3	11.5	1898.1
	THA	799.6	1.9	1.3		22.4	86.5	14.9	0.5	-	80.7	177.6	7.4	1192.8
	IND	615.7	12.4	5.5	26.6		18.2	17.7		-	81.8	41.0	25.3	844.3
	PHI	238.2	16.1	7.6	22.2	27.1		5.6	3.1	-	9.8	9.0	4.9	343.6
	MAL	364.0	4.4	11.0	46.7	26.7	8.9		2.9	-	13.0	94.2	20.2	592.1
	SIN	106.3	14.1	13.6	4.4	-	0.9	15.7		-	45.6	184.6	29.8	415.0
	VN	13.7	13.1	1.7	2.1	2.2	2.3	0.1	2.6		1.0	6.1	2.5	47.5
	NAF	8887.8	340.9	489.9	68.3	44.4	39.7	19.7	46.3	-	37164.3	5191.1	1595.8	53888.2
	EU	2480.7	339.2	139.4	81.0	12.4	15.0	15.7	5.6	-	3527.5	52190.8	1700.5	60507.7
	ROW	2287.1	678.9	133.4	106.9	15.8	5.3	22.3	60.0	-	2347.5	6159.1	1790.4	13606.5
	TOTAL	16894.4	1561.2	1032.1	491.1	205.6	255.1	128.9	123.1	2.3	45514.0	65690.8	5308.2	137206.9

Note: JPN=Japan; KOR=The Republic of Korea; CHI=China; THA=Thailand; IND=Indonesia; PHI=the Philippines; MAL=Malaysia; SIN=Singapore; VN=Vietnam; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

(d) Year 2005

	EXPORTER												
IMPORTER	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN	NAF	EU	ROW	TOTAL
	JPN		247.0	607.9	311.2	162.9	123.6	24.3	3.7	50.7	909.7	1328.4	53.3	3822.8
	KOR	809.4		123.4	11.4	0.3	6.1	3.4	4.5	0.3	453.3	685.1	94.5	2191.8
	CHI	2585.5	1501.0		37.7	33.0	4.9	4.5	1.3	0.0	660.6	1517.3	68.2	6414.1
	THA	1715.3	44.5	30.1		71.0	220.2	62.0	2.3	4.6	65.1	250.2	58.1	2523.3
	IND	651.7	22.5	20.5	149.2		27.0	12.2	16.3	1.7	13.0	57.9	36.0	1007.7
	PHI	310.1	5.3	7.2	19.0	12.9		5.7	5.8	0.1	24.4	25.8	4.1	420.3
	MAL	654.8	24.4	14.7	387.2	165.0	19.4		3.0	0.3	6.6	111.8	49.1	1436.3
	SIN	109.0	19.2	26.3	36.6	11.2	30.1	60.4		2.5	75.2	219.2	58.1	647.8
	VN	56.3	62.0	46.0	36.2	18.3	1.1	2.1	2.7		10.2	39.0	14.0	287.9
	NAF	11172.6	1328.4	2289.1	173.5	68.8	36.5	22.2	43.7	19.7	42874.3	7899.0	2580.3	68508.0
	EU	3648.8	401.7	570.7	77.7	107.0	36.2	34.6	7.5	3.9	3446.6	87723.2	3933.0	99990.9
	ROW	3305.7	1756.8	801.6	639.6	36.5	17.4	94.0	91.4	2.5	2622.3	12556.2	4400.1	26324.0
	TOTAL	25019.1	5412.7	4537.6	1879.3	687.1	522.5	325.3	182.1	86.3	51161.2	112413.1	11348.7	213575.1

Note: JPN=Japan; KOR= The Republic of Korea; CHI=China; THA=Thailand; IND=Indonesia; PHI=the Philippines; MAL=Malaysia; SIN=Singapore; VN=Vietnam; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

(e) Year 2010

	EXPORTER												
IMPORTER	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN	NAF	EU	ROW	TOTAL
	JPN		413.4	1796.3	590.9	284.1	167.5	40.7	3.3	237.9	509.4	1219.0	97.0	5359.5
	KOR	1217.2		900.5	25.6	1.9	9.0	5.3	3.0	11.0	319.6	916.6	130.8	3540.5
	CHI	7056.1	2059.8		50.0	55.2	8.5	54.5	4.6	15.8	700.6	6081.5	165.8	16252.5
	THA	3413.5	166.4	143.2		274.9	328.1	81.5	89.7	13.9	100.0	280.0	147.2	5038.2
	IND	1355.8	32.0	109.7	535.3		28.7	73.6	22.7	5.3	50.8	80.4	48.6	2342.9
	PHI	383.4	31.5	80.4	163.1	76.4		14.4	35.3	2.4	17.4	21.1	8.9	834.3
	MAL	1018.7	24.1	93.7	532.5	150.9	14.0		5.2	1.7	7.8	235.4	39.7	2123.6
	SIN	120.5	25.5	76.5	31.0	9.4	43.9	80.3		7.5	116.3	395.4	48.1	954.4
	VN	136.4	223.5	116.0	157.1	34.0	53.8	6.4	19.6		6.4	128.0	21.5	902.7
	NAF	9718.1	2982.1	5402.7	258.8	78.1	23.6	40.7	22.8	77.7	39834.7	6998.8	1890.5	67328.5
	EU	3771.9	1615.4	2381.9	232.1	73.2	47.2	77.9	14.6	26.2	1994.0	98209.7	5210.1	113654.2
	ROW	4239.2	4076.4	3522.5	1449.2	148.5	63.9	129.2	153.4	19.0	3051.6	19965.8	6540.8	43359.5
	TOTAL	32430.7	11650.0	14623.4	4025.6	1186.5	788.1	604.4	374.1	418.4	46708.6	134531.7	14349.2	261690.6

Note: JPN=Japan; KOR=The Republic of Korea; CHI=China; THA=Thailand; IND=Indonesia; PHI=the Philippines; MAL=Malaysia; SIN=Singapore; VN=Vietnam; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

Annex Table 4.2: Trades of Automobiles in East Asia (US$ million)

(a) Year 1990

	EXPORTER												
IMPORTER	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN	NAF	EU	ROW	TOTAL
	JPN		8.0	0.0	0.2	0.2	0.0	0.0	0.0	-	1083.5	4949.3	7.6	6048.9
	KOR	91.8		0.2	-	-	-	-	0.0	-	93.6	125.2	0.2	310.9
	CHI	144.2	75.9		-	-	-	-	0.1	-	23.8	141.3	95.8	481.0
	THA	877.4	0.1	2.1		-	-	0.0	1.0	-	16.6	251.8	1.5	1150.3
	IND	245.1	0.0	0.0	12.9		-	0.0	-	0.0	17.4	166.1	4.4	445.9
	PHI	354.4	21.7	3.1	0.0	-		0.0	0.5	-	27.7	16.0	1.7	425.0
	MAL	616.9	0.2	1.1	-	1.2	-		5.0	-	31.2	188.4	9.3	853.3
	SIN	349.4	7.7	0.3	0.3	-	-	9.7		-	60.0	194.7	5.1	627.2
	VN	24.5	-	0.3	0.0	0.1	-	-	-		0.0	5.0	3.8	33.7
	NAF	23597.3	1195.1	1.5	28.6	-	-	-	0.0	-	29235.9	10583.2	307.9	64949.4
	EU	11036.4	98.4	0.2	1.0	0.1	-	66.9	1.0	-	1736.9	62057.0	757.6	75755.7
	ROW	8331.9	132.6	43.2	0.3	0.1	0.5	3.0	5.0	1.9	1878.6	9061.0	585.3	20043.5
	TOTAL	45669.0	1539.8	52.0	43.4	1.7	0.5	79.7	12.5	1.9	34205.0	87739.1	1780.2	171124.8

Note: JPN=Japan; KOR=The Republic of Korea; CHI=China; THA=Thailand; IND=Indonesia; PHI=the Philippines; MAL=Malaysia; SIN=Singapore; VN=Vietnam; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

(b) Year 1995

	EXPORTER												
IMPORTER	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN	NAF	EU	ROW	TOTAL
	JPN		2.2	0.4	4.0	0.4	0.2	0.1	0.0	-	3072.6	5912.3	52.3	9044.6
	KOR	37.5		0.4	-	-	-	-	-	0.0	136.8	338.4	1.0	514.1
	CHI	468.6	174.9		-	-	-	0.2	0.7	2.5	131.9	766.7	65.6	1611.1
	THA	1623.0	126.2	1.6		0.5	0.2	0.1	0.7	-	74.7	964.3	36.4	2827.6
	IND	433.9	44.2	3.6	0.2		-	0.0	-	-	61.1	242.3	18.4	803.6
	PHI	644.8	92.7	2.3	0.2	-		9.3	2.8	0.0	45.0	34.4	2.4	833.9
	MAL	984.7	8.4	2.4	-	9.9	-	-	17.9	-	17.0	454.6	18.6	1513.5
	SIN	551.9	15.0	1.7	0.7	-	-	17.0		0.9	88.9	529.5	19.1	1224.8
	VN	95.2	95.5	10.6	0.2	7.3	0.2	1.4	4.2		33.5	20.3	124.4	392.8
	NAF	23311.8	1654.0	7.1	0.0	-	-	0.1	-	-	50826.9	10885.3	68.7	86753.8
	EU	9590.4	2217.7	3.0	53.3	-	0.0	99.6	6.4	0.0	2279.6	84364.7	950.1	99564.9
	ROW	11588.8	2652.3	115.7	8.5	1.6	4.0	25.3	13.6	0.7	5784.4	16752.3	2905.8	39852.8
	TOTAL	49330.5	7083.0	148.7	67.1	19.7	4.6	153.1	46.3	4.2	62552.3	121265.2	4262.8	244937.6

Note: JPN=Japan; KOR=The Republic of Korea; CHI=China; THA=Thailand; IND=Indonesia; PHI=the Philippines; MAL=Malaysia; SIN=Singapore; VN=Vietnam; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

(c) Year 2000

	EXPORTER												
IMPORTER	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN	NAF	EU	ROW	TOTAL
	JPN		9.4	0.6	1.5	0.7	4.0	0.2	-	-	1383.8	5138.5	133.0	6671.7
	KOR	54.2		1.8	-	-	-	-	0.0	-	60.6	171.8	2.7	291.1
	CHI	563.0	59.2		0.5	-	0.0	-	0.5	-	58.8	291.7	25.2	999.1
	THA	403.4	28.0	0.9		1.6	1.2	0.3	0.0	0.0	11.8	205.5	19.2	672.1
	IND	247.3	181.3	3.4	7.0		-	9.4	-	-	27.7	101.3	67.5	644.9
	PHI	268.7	87.0	2.0	12.3	0.5		0.2	1.7	-	81.4	33.7	5.8	493.1
	MAL	639.5	56.2	1.2	0.0	1.7	0.0		4.5	-	3.3	205.0	21.6	933.0
	SIN	824.0	103.5	0.3	22.7	-	-	13.6		-	30.1	309.4	34.6	1338.2
	VN	98.3	112.1	5.8	0.2	0.1	-	-	0.4		1.9	6.5	12.1	237.4
	NAF	33450.3	5153.9	9.1	0.0	0.1	-	0.2	0.2	-	80217.5	23323.2	1226.0	143380.4
	EU	10206.2	3055.5	4.1	665.6	0.2	0.0	44.0	2.7	-	3665.3	131396.5	2297.4	151337.4
	ROW	13852.6	2939.9	108.4	718.9	6.4	0.0	27.3	25.7	-	3533.0	20068.6	4928.5	46209.3
	TOTAL	60607.6	11786.0	137.5	1428.6	11.2	5.3	95.2	35.8	0.0	89075.3	181251.6	8773.6	353207.6

Note: JPN=Japan; KOR=The Republic of Korea; CHI=China; THA=Thailand; IND=Indonesia; PHI=the Philippines; MAL=Malaysia; SIN=Singapore; VN=Vietnam; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

(d) Year 2005

	EXPORTER												
IMPORTER	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN	NAF	EU	ROW	TOTAL
	JPN		42.7	11.3	56.9	1.7	0.5	0.8	0.7	0.2	861.7	5811.0	925.6	7712.9
	KOR	301.1		2.6	0.1			0.1		0.0	129.7	951.9	77.1	1462.4
	CHI	1438.4	402.8		0.9	0.0		0.2	0.1		537.7	2261.5	149.9	4791.4
	THA	593.2	29.4	8.2		79.3	105.3	0.1	0.2	0.0	22.8	210.8	22.3	1071.6
	IND	372.6	85.0	14.8	482.2		20.1	1.9	120.2		108.6	153.9	86.7	1446.0
	PHI	216.3	79.1	4.5	280.3	52.2		1.3	2.2		31.0	39.2	6.5	712.9
	MAL	830.1	562.4	19.6	45.3	41.3	3.0		1.9	0.2	3.7	302.5	37.8	1847.8
	SIN	946.8	176.3	3.2	225.6	1.3	0.9	12.9			158.6	423.4	72.1	2021.1
	VN	187.7	212.8	64.6	14.3	2.8	19.8	0.1	6.1		33.4	15.0	115.0	671.7
	NAF	38738.2	9659.3	217.9	0.3		0.1	0.1	0.1	5.0	89438.3	34832.1	3197.7	176089.0
	EU	14275.7	8507.9	217.7	903.9	0.1	0.2	30.3	19.2	0.5	7603.6	227006.8	8028.9	266594.7
	ROW	26584.6	7776.3	1089.4	2616.0	53.6	0.3	44.8	103.1	1.2	9257.7	40058.6	14316.4	101902.1
	TOTAL	84484.6	27533.9	1653.6	4625.7	232.4	150.2	92.5	253.8	7.2	108186.8	312066.9	27036.0	566323.5

Note: JPN=Japan; KOR=The Republic of Korea; CHI=China; THA=Thailand; IND=Indonesia; PHI=the Philippines; MAL=Malaysia; SIN=Singapore; VN=Vietnam; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

(e) Year 2010

	EXPORTER												
IMPORTER	country	JPN	KOR	CHI	THA	IND	PHI	MAL	SIN	VN	NAF	EU	ROW	TOTAL
	JPN		25.0	20.5	339.8	29.2	0.1	0.6	0.0	0.1	477.2	4883.0	390.4	6165.8
	KOR	613.2		8.8	0.7	0.1	0.0	0.2	0.0	0.4	436.3	2455.5	79.0	3594.2
	CHI	6901.3	1462.6		1.9	0.5		0.2			3844.7	15412.0	29.4	27652.7
	THA	963.7	85.4	48.6		181.1	111.9	58.9	0.9		58.3	199.7	30.1	1738.5
	IND	1500.4	62.5	62.7	1060.9		8.8	32.9	334.8	0.1	16.5	208.2	119.2	3407.1
	PHI	627.4	200.9	54.0	872.3	153.0		0.8	5.5	0.1	31.8	63.0	40.2	2048.9
	MAL	1349.4	247.9	64.2	830.9	88.0	5.3		0.0	0.0	24.7	533.1	99.1	3242.5
	SIN	359.9	103.6	32.3	39.1	7.5	0.1	34.5			167.9	796.4	145.1	1686.5
	VN	194.9	649.8	350.1	45.4	13.6	0.6	1.1	2.4		292.9	90.8	512.0	2153.6
	NAF	35659.3	8057.9	179.6	44.5		0.0			5.8	91491.7	28401.2	3204.7	167044.8
	EU	11441.6	3423.0	513.9	780.3	4.4	0.0	11.1	2.1	5.5	9879.6	212616.3	11951.8	250629.5
	ROW	34665.7	16142.3	4512.2	7089.2	374.4	0.5	52.6	42.6	14.6	20788.4	56175.3	21724.7	161582.4
	TOTAL	94276.8	30461.0	5846.8	11104.8	851.6	127.3	192.9	388.4	26.8	127509.9	321834.5	38325.8	630946.4

Note: JPN=Japan; KOR=The Republic of Korea; CHI=China; THA=Thailand; IND=Indonesia; PHI=the Philippines; MAL=Malaysia; SIN=Singapore; VN=Vietnam; NAF=NAFTA; EU=European Union; ROW=Rest of the World.

CHAPTER 5 : MEASURING THE NATURE OF EAST ASIA'S AUTOMOBILE PRODUCTION NETWORKS

5.1 Introduction

Integration of countries or regions into the worldwide exchange network is one of the significant phenomena of globalisation. In the East Asian region, increases in trade, particularly in terms of P&C among countries under the IPNs, are one of the important factors behind world trade becoming more increasingly integrated now than ever before (Kimura, 2006; Kimura and Obashi, 2011). Accordingly, countries such as Vietnam, Thailand and the Philippines, which formerly were merely buyers of various final products, have become members of the global production network and are now engaged in the activity of import and export of P&C. The rapid increase in integration network among countries in the East Asian region, particularly in high-technology industries such as the automobile industry, has led to trade networks in that industry becoming increasingly complex over time. This situation has led many researchers in the field of economics such as Kali and Reyes (2007), Fagiolo et al. (2007a, 2007b), Fagiolo et al. (2008), Tang and Wagner (2010) to concentrate on the network of trade structure.

In chapter 4, we have built network diagrams of East Asia's automobile production networks between 1990 and 2010 in an effort to understand the structure of East Asia's automobile production networks. In this chapter, we developed summary indices that characterise that structure and the place of individual countries within them so as to facilitate discussion of the nature and development of such networks. This chapter is structured as follows: Section 5.2 discusses the basic concept of

network. Sections 5.3 and 5.4 respectively discuss the research methodology and findings of the chapter. Finally, Section 5.5 draws the conclusions.

5.2 The basic concept of network

Compared to other disciplines, the study of networks took place earlier in the field of sociology and mathematics. Thereafter, it has been studied extensively in other areas such as biology, computer science and physics. In recent years, the study of networks has become very popular in economics (Goyal, 2007). As in other disciplines, in principle, a network consists of a set of nodes or vertices, and those nodes are normally connected by a set of links[44]. Specifically, in international trade a "country" is considered to be a network node, while the monetary values of exports or imports are analogous to valued links.

Links between countries in a network can be either non-directed or directed, and may also be valued by weight or magnitude. In the case of non-directed relationships between nodes, these are conceptualised in terms of binary variables (i.e., $a_{ij} \in \{0,1\}$), where a_{ij} takes the value of one if a relationship exists between i and j; otherwise, it takes zero[45]. A drawback of the non-directed approach is that it does not distinguish between the link from i to j and that from j to i. In the case of a directed network, however, the relationships between two countries can be distinguished either from i to j and/or from j to i. For example, country i exports to country j and/or country j exports to country i. In this case, if a_{ij}=1, then there is a flow of information from i to j and at the same time we allow for a_{ji}=0 even if a_{ij}=1.

[44]A similar definition is used in Fagiolo et al. (2007a), Kali and Reyes (2007), and Fagiolo et al. (2007b).
[45]This condition is the same for a_{ji}.

5.3 Methodology

In the previous chapter, we have mapped the topology of East Asian automobile trading system as interdependent complex networks for the period 1990-2010. In this chapter, we will use social network methods to measure and analyse the complexity of those networks at both global and country level in order to understand the nature of these networks and how they have evolved over the last 20 years. Consequently, to understand the nature of a dominance-dependence relationship in such interdependent complex networks, we have developed dominance indices to gauge the degree of domination among East Asian countries.

5.3.1 Global-level analysis

The global-level analysis provides measures of total network sizes. In the global-level analysis of the directed links, we will use both a binary and weighted approach when analysing the network's complexity. We have carried out these two analyses because both analyses could complement each other. In the binary approach, important trade links are assumed to either exist or not, while in the weighted analysis values will be given to those links. In both analyses, we only count trade flows that have previously been deemed important in the analysis by Piana (2006).

In Piana (2006), a trade flow is deemed to be important when at least one party (i.e., country) assumes that the flow with her trading partner is important. This means that important trade flow would not exist if both parties consider that trade between them is not important. In this respect, we can say that the important trade flow reflects the existence of dependence or interdependence (if both parties assume that trade

between them is important) between two countries, and this relationship is relevant in the case of intra-industry trade.

5.3.1.1 Binary network analysis (BNA)

BNA is an approach that measures the existence of a network using the binary approach. When two countries, say country *i* and country *j*, are connected by a link {*i*,*j*}, they are called adjacent. In the binary approach, the adjacency relation is quantified by the term a_{ij}=1, where the value of exports from country *i* to country *j* as a proportion of country *i*'s total exports is greater than or equal to a given threshold value. On the other hand, the non-adjacency one is quantified by a_{ij}=0, where the value of exports from country *i* to country *j* as a proportion of country *i*'s total exports is smaller than a given threshold value. The same rules will apply to a_{ji} but we only discuss here the case of a_{ij}. By using the adjacency matrix, one can calculate the total nodes' degree (i.e. the number of links that exist in a network) using the following formula:

$$B(G) = \sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij} \qquad (5.1)$$

where,

$B(G)$= total nodes' degree

i = country i

j = country j (i.e., country i's trading partner)

N = total number of countries in the network.

In addition, by using the adjacency matrix one can provide some generalised descriptors of network connectivity, such as average degree and connectedness, as follows:

$$\overline{B(G)} = \frac{B(G)}{N} \tag{5.2}$$

where,

$\overline{B(G)}$ = average degree

and the rest of variables are defined as in equation (5.1).

$$BConn = \frac{B(G)}{N^2} \tag{5.3}$$

where,

$BConn$ = connectedness

and the rest of variables are defined as in equation (5.1).

For example, there are six countries in a network and there exist 14 node degrees. Thus, $\overline{B(G)} = \frac{14}{6} = 2.333$. Meanwhile, connectedness measures the relative network connectivity. The values of connectedness ranged from zero to one. After multiplying by 100, the values ranged from 0 percent to 100 percent. Thus, $BConn = \frac{14}{36} = 0.389$ or 38.9 percent. Different to previous studies[46], the directed links between a country and its partner(s) in our study are based on how important that country is to its partner(s).[47] In this study, we are not using specifically the exact value of exports and imports when charting the structure of the network. As stated in

[46]For example, Kali (2007) used either export or import data to identify the existence of a link between two countries. In other words, Kali (2007) looks at it from the perspective of either an exporter or importer.

[47]In this study, we used both export and import data to identify such an important link from the perspective of both exporter and importer.

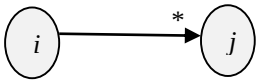
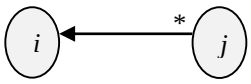
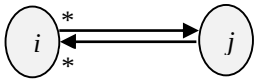
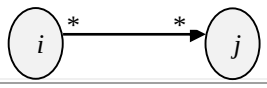
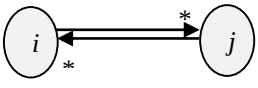
the previous chapter, we define a trade-link between country *i* and country *j* to be present if the value of exports from country *i* to country j as a proportion of country *i*'s total exports is greater than the 15 percent threshold. This is also the same for the case of imports as well as in the weighted analysis that will be discussed in Section 5.3.1.2. The advantage of using this approach is that it enables us to examine the structure and evolution of the trade network for different levels of trade.

Examining how the structure of the network changes with the trade threshold used to define the presence of links also enables us to understand the sensitivity of various topological characteristics of the network to different trade magnitudes. Constructing the network for different thresholds enables us to incorporate both magnitude and network features in our analysis. Using threshold enables us to avoid working directly with valued-directed links even though implicitly this threshold embodies the values of the trade links in our data.

In this study, we use Piana's approach wherein we identify a trade link between country *i* and *j* to be present if the value of exports from country *i* to country *j* as a proportion of country *i*'s total exports is greater than or equal to a given threshold value. In this study, we attribute the link to the exporter if the associated trade flow is important to either (or both) partner(s) rather than attribute the existence of a trade link to a country whenever it is important to that country. For example, we define a_{ij}=1 when the exports of country *i* are considered important by either country *i* or country *j* (i.e. country *j* is an important export market for country *i* or country *i* is an important source of imports for country *j*) rather than a_{ij}=1 when country *i* is important for country *j*. This is because we are able to distinguish the important links that exist based on their role of either as a market destination or input source or both.

As shown in Table 5.1 below, there exist nine possible directed networks that can be created from the code, and some codes can envisage more than one existing link between two countries.[48]

Table 5.1: Binary Values Based on the Countries' Relationship Code

Relationship code	a_{ij}	a_{ji}
0100 0001 	1	0
Code 0100 (0001). This code implies that a_{ij}=1 and a_{ji}=0. This is because the direction of exports is from country *i* to country *j*, wherein country *j* relies upon its partner (country *i*) as an import source. In this case, the link is only important for country *j* but not for country *i.*		
1000 0010 	0	1
Code 1000 (0010). This code shows that a_{ij}=0 and a_{ji}=1. In this case, the direction of export flow only exists from country *j* to country *i*, wherein country *j* relies upon country *i* as a market destination. Again, in this case, the link is only important for country *j* but not for country *i.*		
0011 1100 	1	1
Code 0011 (1100). This code indicates that both a_{ij} and a_{ji} are equal to 1. In this case, there exist two directions of export flow. One is from country *i* to country *j*, and the other is from country *j* to country *i*. In this relationship, country *i* relies upon country *j*, both as an import source and market. This link is only important for country *i* but not for country *j*.		
0110 1001 	1	0
Code 0110 (1001). This code implies that a_{ij}=1 and a_{ji}=0. The direction of export flow is only from country *i* to country *j*. In this relationship, country *i* relies upon its partner (i.e., country *j*) as a market destination, while its partner relies on her as an import source. In this case, this link is crucial to both parties.		
0101 	1	1
Code 0101. This code indicates that both a_{ij} and a_{ji} are equal to 1. In other words, this code envisages that there exist two directions of export flow. One is from country *i* to		

[48]Those nine possible directed networks have been defined in Chapter 4.

Relationship code	a_{ij}	a_{ji}
country *j*, and the other from country *j* to country *i*. In this relationship, country *i* and country *j* rely on each other as import sources, and this link is important to both parties.		
1010 * i * j *	1	1
Code 1010. This code tells us that both a_{ij} and a_{ji} are equal to 1. In other words, there exist bilateral trade flows between these two countries. One is from country *i* to country *j*, and the other is from country *j* to country *i*. In this link, countries *i* and *j* rely on each other as import markets, and this link is important to both parties.		
1111 * * i * * j	1	1
Code 1111. This code also indicates that both a_{ij} and a_{ji} are equal to 1. In this respect, there exist two directions of export flow between countries *i* and *j*. One is from country *i* to country *j*, and the other is from country *j* to country *i*. In this relationship, countries *i* and *j* rely on each other in terms of both import source and market, and this link is important to both parties.		
0111 1101 * * i * j	1	1
Code 0111 (1101). This code indicates that both a_{ij} and a_{ji} are equal to 1, which also means that there exist two directions of export flow between countries *i* and *j*. One is from country *i* to country *j*, and the other is from country *j* to country *i*. In this relationship, however, country *i* relies on country *j* in terms of both import source and market, while country *j* relies on country *i* as an import source. This link is important to both parties.		
1011 1110 * i * * j *	1	1
Code 1011 (1110). This code implies that both a_{ij} and a_{ji} are equal to 1. In this case, there exist two directions of export flow. One is from country *I* to country *j*, and the other is from country *j* to country *i*. In this relationship, country *I* relies on country *j* in terms of both import source and market, while country *j* relies on country *I* as a market destination. This link is important to both parties.		

Notes: (1) Arrows denote direction of trade flow.
*(2) *indicates that the country considers the link to be important.*
(3) Codes in parentheses refer to situations where the roles of the two countries are reversed.

5.3.1.2 Weighted network analysis (WNA)

The above binary network indices only measure the number of links while ignoring the volume as well as the distribution of those links. To overcome this deficiency, we

used a weighted network analysis (WNA). WNA is defined as an approach that measures the existence of a network based on the value of exports (or imports). By using this approach, one can calculate the node strength in a network using the following formula:

$$W(G) = \sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij} \tag{5.4}$$

where,

$W(G)$ = node strength

w_{ij} = weighted link

i = country i

j = country j (i.e., country i's trading partner)

N = total number of countries in the network.

Again, in the weighted approach, by using the adjacency matrix one can also provide some generalised descriptors of network connectivity such as average strength ($\overline{W(G)}$) and weighted connectedness ($WConn$) as follows:

$$\overline{W(G)} = \frac{W(G)}{N} \tag{5.5}$$

where,

$\overline{B(G)}$ = average degree

and the rest of variables are defined as in equation (5.4).

$$WConn = \frac{W(G)}{N^2} \tag{5.6}$$

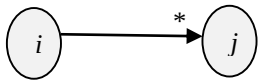
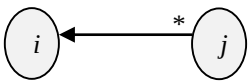
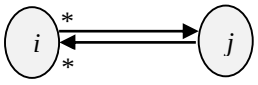
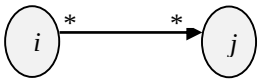
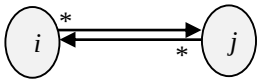
where,

WConn = weighted connectedness

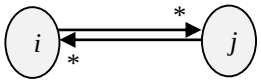
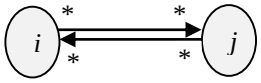
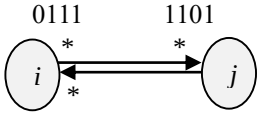
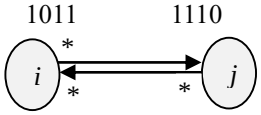
and the rest of variables are defined as in equation (5.4).

In this study, the weighted link is based on the type of relationship between two countries (see Table 5.2). This means that the relationship code would determine the existence of a directed link between two countries (as in the binary approach), while the strength of the link would be represented by the value of exports (or imports) between those two countries.[49] This export (import) values are only taken into account if there exist important links between two countries. Therefore, node strength [$W(G)$] is not necessarily equal to the total volume of trade in automobile. In this respect, some paired countries would have a reciprocal relationship, while others would not. Besides, the magnitude of the link in each pair would also be different.

Table 5.2: Weighted Values Based on the Countries' Relationship Code

Relationship code	w_{ij}	w_{ji}
0100 0001 	X_{ij}	0
1000 0010 	0	M_{ij}
0011 1100 	X_{ij}	M_{ij}
0110 1001 	X_{ij}	0
0101 	X_{ij}	M_{ij}

[49]Tang and Wagner (2007) also used the value of exports as weighted.

Relationship code	w_{ij}	w_{ji}
1010 	X_{ij}	M_{ij}
1111 	X_{ij}	M_{ij}
0111 1101 	X_{ij}	M_{ij}
1011 1110 	X_{ij}	M_{ij}

Notes: (1) Arrows denote direction of trade flow.
*(2) *indicates that the country considers the link to be important.*

5.3.2 Specific-country analysis

In the above global-level analysis, we focus on the network as a whole and not on the nature of relationships for any specific country. In fact, conducting the analysis at the country-level will allow us to form a picture of the general structure of the network and its properties, such as: (1) the extent to which a country is integrated in a network; (2) who is the influential actor(s) in a network; (3) core-periphery relationships in a network. In this study, we use a node degree centrality index and node strength centrality index to understand the structure of East Asia's automobile networks.

5.3.2.1 Node degree centrality (NDC)

NDC refers to the number of ties a country has to other countries. In this respect, countries that have more ties would be characterised as influential and prominent as they may have multiple, alternative ways and resources to achieve their goals. Node

degree centrality was proposed by Nieminen (1974) to measure the relevance or influence that a country has in a network based on its interaction or degree of connectedness (Koschutzki et al., 2005; Freeman, 1979). This index is based on binary analysis, and the formula for this index may be given as follows:

$$NDC_i = \sum_{j=1}^{N} a_{ij} + a_{ji} \tag{5.7}$$

In this study, both a_{ij} and a_{ji} are equal to 1 when there exists a reciprocal relationship between country *i* and country *j*; for example, those with codes 0011, 0101, 1010, 1111, 0111 and 1011 (see Table 5.1). In contrast, a_{ij} would take the value of 0 when a_{ji}=1 or vice-versa when there exists a unidirectional relationship between country *i* and country *j*; for example, those with codes 0001, 0010 and 0110 (see Table 5.1).

By using NDC, we can also calculate the network density (ND) of a country using the following formula:

$$ND_i = \frac{NDC_i}{2(N-1)} \tag{5.8}$$

where N is the number of countries in the network, and ND is simply the fraction of links that are actually present out of all possible ones.

5.3.2.2 Node strength centrality (NSC)

We proceed with the weighted analysis since the binary one does not consider the difference between strong links and weak ones. In the weighted analysis, we use NSC index to calculate the strength of links between a country and its partner(s). NSC refers to the sum of weights of a country's direct ties to other countries. In this respect, countries with bigger weights would be characterised as influential and

prominent as they may have multiple, alternative ways and resources to reach their goals. The formula for this index may be laid out as follows:

$$NSC_i = \sum_{j=1}^{N} w_{ij} + w_{ji} \tag{5.9}$$

In the weighted case, $w_{ij}=x_{ij}$ and $w_{ji}=x_{ji}$ when there exists a reciprocal relationship between country *i* and country *j*. Again, examples of this are those with codes 0011, 0101, 1010, 1111, 0111 and 1011 (see Table 5.2). In contrast, w_{ij} would take the value of 0 when $w_{ji}=x_{ji}$ or w_{ji} would take the value of 0 when $w_{ij}=x_{ij}$ and if there exists a unidirectional relationship between country *i* and country *j*; for example, those with codes 0001, 0010 and 0110 (see Table 5.2).

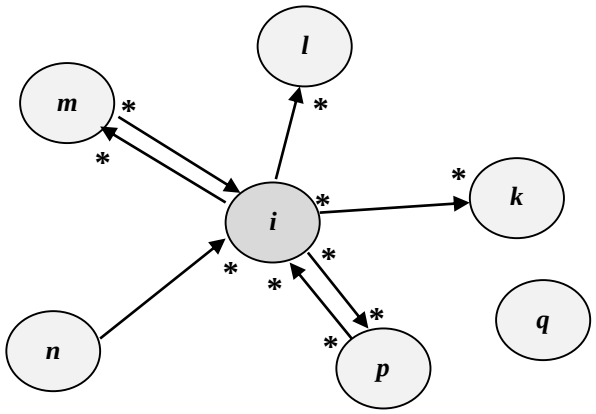
5.3.3 Network domination by country

After understanding the nature and complexity of East Asia's automobile networks, we then tried to investigate the dominating power of each country in the network by developing dominant indices, and to see how they evolved between 1990 and 2010. Again, we will use both binary and weighted approaches in these analyses.

5.3.3.1 Binary analysis

After considering the importance of each country in East Asia's automobile network, we are now interested in studying each country's domination over its partner(s) in the network. Figure 5.1 illustrates a sub-network that envisages the relationship between country *i* and its trading partners (viz. countries *k, l, m* and *p*), while country q (a member of the network) does not have any trade relationship with country *i*.

Figure 5.1: The Relationship between Country *i* and Its Partners in the Sub-Network



(1) Arrows denote direction of trade flows.
*(2) *indicates the country whose concerned on the link.*

The relationship between country *i* and its partners in the sub-network is described as follows:

1. For country *i*, the relationship with country *k* is important since the latter is a major market destination; at the same time, for country *k* the relationship with country *i* is important as the latter is a major import source. In this unidirectional relationship, we can see that the same flow of goods is important for both parties, and there is integration between country *i* and country *k*. In this respect, one is able to recognise that there is no dominance-dependence relationship between *i* and *k*.

2. For country *i*, the relationship with country *l* is not important, whereas for country *l* the relationship with country *i* is important as the latter is a major import source. In this unidirectional relationship, one can observe that there is domination by country *i* of its trading partner (country *l*) as an exporter.

3. For country *i*, the relationship with country *m* is not important, whereas for country *m* the relationship with country *i* is important as the latter is a major import source and export destination. In this bidirectional relationship, we can see domination by country *i* of its trading partner (country *m*) as both exporter and importer.

4. For country *i*, the relationship with country *n* is important as the latter is a major import source, whereas for country *n* the relationship with country *i* is not important. In this unidirectional relationship, we can see the dependency of country *i*on its trading partner (country *n*) as an importer.

5. For both countries (*i* and *p*), their mutual relationship is important in terms of both import source and market destination. In this bidirectional relationship, we can see that the flow of goods is important for both parties and there exists a trade integration between country *i* and country *p*. In this respect, one can see that there is no dominance-dependence relationship between country *i* and country *p*.

6. There is no relationship between country *i* and country *q*. It means that there is no trade between these two countries.

These six concepts are adapted from Piana (2006). Piana's approach has been chosen because it can present the position of countries in a hierarchical structure based solely on countries' bilateral relationship with their trading partners.

In this study, we assume that country *i* would have dominant features if its partner(s) consider their relationship with her to be important (i.e., either as a major export destination or as a major import source); at the same time, country *i* does not

consider any relationship with her partners to be important. Based on this assumption, we can calculate the dominant intensity power that country *i* has in its relationships with partners. To do so, we need to acquire information about: (1) the number of export (or import) links that tie country *i* and its partners; (2) the frequency that country *i*'s partner is concerned[50] about its relationship with country *i*; (3) the frequency that country *i* is concerned about the relationship with her partner; (4) the possible number of export (import) links that exists if all partners have export (import) links with country *i*[51] (which is equal to (N-1)[52]). Table 5.3 below summarises the information regarding the relationship between country *i* and each of its trading partners.

Based on the second column in Table 5.3, we can see that country *i* has four export links with its partners in that sub-network, while the third column indicates three import links that tie country *i* and its partners. Therefore, the number of country *i*'s export (import) links, as a proportion of the number of possible export (import) links that would exist if all partners have export (import) transactions with country *i*, can be written as $\frac{a_{ij}}{N-1}$ for export side analysis and $\frac{a_{ji}}{N-1}$ for import side analysis. Based on the fourth column in Table 5.3, we can see that the total score at which country *i* matters to its partners (ϕ_{ij}) is 6, while the fifth column shows that the total score at which country *i*'s partner matters to her (ϕ_{ji}) is 4. Therefore, the total frequency of links for which country *i* matters to its partner in terms of the total frequency of concern that both country *i* and its partner have in that sub-network can be written as follows: $\phi_{ij}/(\phi_{ij}+\phi_{ji})$.

[50]The word "concerned" in this study means that it matters or important to a country.
[51]This is a situation where the relationship between country *i* and each of her partners is $a_{ij}=1$ for the export side and $a_{ji}=1$ for the import side.
[52]N is the number of countries in the network.

Table 5.3: Information about Relationships between Country *i* and Its Partners

(1)	(2)	(3)	(4)	(5)
Country *i*'s partner	Number of export links that ties country *i* and its partners (a_{ij})	Number of import links that ties country *i* and its partners (a_{ji})	The frequency at which country *i*'s partner is concerned about its relationship with country *i* (ϕ_{ij})	The frequency at which country *i* is concerned about the relationship with her partner (ϕ_{ji})
k	1	0	1	1
l	1	0	1	0
m	1	1	2	0
n	0	1	0	1
p	1	1	2	2
q	0	0	0	0
	$\sum_{j=1}^{N} a_{ij} = 4$	$\sum_{j=1}^{N} a_{ji} = 3$	$\sum_{j=1}^{N} \phi_{ij} = 6$	$\sum_{j=1}^{N} \phi_{ji} = 4$

Based on the information above, we developed domination degree indices (from the export and import side) for country *i* as follows:

$$DDI_i^X = \left(\frac{\sum_{j=1}^{N} a_{ij}}{N-1} \right) \left(\frac{\sum_{j=1}^{N} \phi_{ij}}{\sum_{j=1}^{N} \phi_{ij} + \sum_{j=1}^{N} \phi_{ji}} \right) \tag{5.10}$$

$$DDI_i^M = \left(\frac{\sum_{j=1}^{N} a_{ji}}{N-1} \right) \left(\frac{\sum_{j=1}^{N} \phi_{ij}}{\sum_{j=1}^{N} \phi_{ij} + \sum_{j=1}^{N} \phi_{ji}} \right) \tag{5.11}$$

From equations 5.10 and 5.11, we can see that both indices consist of two ratios: (1) the number of export (import) links in relation to their total possible links; (2) the total number at which country *i* matters to its partner relative to the total frequency of concern that both country *i* and its partners have. The former ratio measures the

export (import) intensity of country *i*, wherein the larger the ratio the greater the degree of country *i*'s export (import) intensity. Meanwhile, the second ratio measures how frequently country *i* dominates her trading partner(s) in each relationship it has in (1). And again, the more frequent country *i* dominates her partner in each link, the higher is her influence on that partner. A combination of these two factors is necessary for developing a solid domination index. For example, Japan has eight important export links in auto P&C (export intensity = 8/11=0.72), and seven out of eight links matter to its partners (second ratio = 7/8=0.88). Therefore, $DDI_i^X = 0.72 \times 0.88 = 0.63$. In another case, only one out of eight links matters to its partners (second ratio = 1/8 = 0.12). Therefore, $DDI_i^X = 0.72 \times 0.12 = 0.09$, wherein this figure is smaller than the previous one. Based on the above example, the information about both ratios is crucial to gauging a country's dominating power.

Both DDI_i^X and DDI_i^M are non-negative indices and have a value range from zero to one. From the export side, $DDI_i^X = 0$, indicating that country *i* does not have any dominating power as an exporter in its relationship with partner(s), while $DDI_i^X = 1$ indicates that country *i* has maximum dominating power as an exporter over its partners in the network.[53] Meanwhile, from the import side, $DDI_i^M = 0$ which indicates that country *i* does not have any dominating power as an importer in its relationship with partner(s), while $DDI_i^M = 1$ indicates that country *i* has maximum dominating power as an importer over its partners in the network.

[53]Countries with the highest score in both (1) and (2) have the highest dominant power in the network compared to those who have the highest score in either (1) or (2).

5.3.3.2 Weighted Analysis

The above analysis used a binary approach at 15 percent threshold. As a compliment to the binary analysis, we then conducted a weighted analysis[54]. In this respect, we will conduct two types of analyses: (1) export side analysis (i.e., country *i* serves as an exporter, while its partner serves as an importer); (2) import side analysis (i.e., country *i* serves as an importer, while its partner serves as an exporter). Again, to calculate the dominating power using a weighted approach, we needed to acquire the following information:

- Export side analysis: (1) country *i* is considered as an important exporter by her partner(s) in the network (represented by the import share automobile of country *i*'s partner(s)); (2) country *i* considers her partner(s) to be an important importer in the network (represented by export share of automobile of country *i*); (3) export of country *i*'s auto P&C (final automobiles) compared to the global export of auto P&C (final automobiles). Information about (1) and (2) are summarised in columns 2 and 3 in Table 5.4, respectively.

- Import side analysis: (1) country *i* is considered as an important importer by her partner(s) in the network (represented by the export share automobile of country *i*'s partner(s)); (2) country *i* considers her partner(s) to be an important exporter in the network (represented by import share of automobile of country *i*); (3) import of country *i*'s auto P&C (final automobiles) compared to the global import of auto P&C (final automobiles). Information

[54]In this weighted analysis we take into account all links that exist between country *i* and its partners.

about (1) and (2) are summarised in columns 2 and 3 in Table 5.5, respectively.

Table 5.4: Information about Relationship between Country *i* and Its Partners Based on Export Side Analysis Using a Weighted Approach

Country *i*'s partner	Import share of automobile of country *i*'s partner	Export share of automobile of country *i*
k	$\frac{M_{ki}}{M_k^{tot}}$	$\frac{X_{ik}}{X_i^{tot}}$
l	$\frac{M_{li}}{M_l^{tot}}$	$\frac{X_{il}}{X_i^{tot}}$
m	$\frac{M_{mi}}{M_m^{tot}}$	$\frac{X_{im}}{X_i^{tot}}$
n	$\frac{M_{ni}}{M_n^{tot}}$	$\frac{X_{in}}{X_i^{tot}}$
p	$\frac{M_{pi}}{M_p^{tot}}$	$\frac{X_{ip}}{X_i^{tot}}$
q	$\frac{M_{qi}}{M_q^{tot}}$	$\frac{X_{iq}}{X_i^{tot}}$
Total	$\sum_{j=1}^{N}\frac{M_{ji}}{M_j^{tot}}$	$\sum_{j=1}^{N}\frac{X_{ij}}{X_i^{tot}}$

Table 5.5: Information about Relationship between Country *i* and Its Partners Based on Import Side Analysis Using Weighted Approach

Country *i*'s partner	Export share of automobile of country *i's* partner	Import share of automobile of country *i*
k	$\frac{X_{ki}}{X_k^{tot}}$	$\frac{M_{ik}}{M_i^{tot}}$
l	$\frac{X_{li}}{X_l^{tot}}$	$\frac{M_{il}}{M_i^{tot}}$
m	$\frac{X_{mi}}{X_m^{tot}}$	$\frac{M_{im}}{M_i^{tot}}$
n	$\frac{X_{ni}}{X_n^{tot}}$	$\frac{M_{in}}{M_i^{tot}}$
p	$\frac{X_{pi}}{X_p^{tot}}$	$\frac{M_{ip}}{M_i^{tot}}$
q	$\frac{X_{qi}}{X_q^{tot}}$	$\frac{M_{iq}}{M_i^{tot}}$
Total	$\sum_{j=1}^{N}\frac{X_{ji}}{X_j^{tot}}$	$\sum_{j=1}^{N}\frac{M_{ij}}{M_i^{tot}}$

Based on the information in Table 5.4, we developed a domination intensity index (DII) for country *i* as follows:

$$DII_i^X = \sum_{j=1}^{N} \frac{X_{ij}}{X_W} \left[\frac{\sum_{j=1}^{N} \frac{M_{ji}}{M_j^{tot}}}{\sum_{j=1}^{N} \frac{M_{ji}}{M_j^{tot}} + \sum_{j=1}^{N} \frac{X_{ij}}{X_i^{tot}}} \right] \tag{5.11}$$

Since $\sum_{j=1}^{N} \frac{X_{ij}}{X_i^{tot}} = 1$, we can write equation (5.11) as:

$$DII_i^X = \sum_{j=1}^{N} \frac{X_{ij}}{X_W} \left[\frac{\sum_{j=1}^{N} \frac{M_{ji}}{M_j^{tot}}}{\sum_{j=1}^{N} \frac{M_{ji}}{M_j^{tot}} + 1} \right] \tag{5.12}$$

As we can see in equation (5.12), DII_i^X comprises two ratios: (1) export of automobile from country *i* in terms of the global export of automobile; (2) total automobiles imported by country *i*'s partner(s) from country *i* in terms of its partner(s)' total imports of automobiles respectively divided by the aforesaid ratio plus one. The former ratio measures the strength of country *i*'s export of automobiles to its partner(s). Meanwhile, the second ratio measures the degree of dependency of country i's partner(s) towards country *i* as an input source. In this respect, the higher the ratio the greater the dominating powers of country *i* as an input source. The DII_i^X index has a minimum value of zero which indicates that country *i* does not have any dominating power as an input source. Meanwhile, the higher the DII_i^X possessed by a country, the greater the dominating power as an input source that that country has.

$$DII_i^M = \sum_{j=1}^{N} \frac{M_{ij}}{M_W} \left[\frac{\sum_{j=1}^{N} \frac{X_{ji}}{X_j^{tot}}}{\sum_{j=1}^{N} \frac{X_{ji}}{X_j^{tot}} + \sum_{j=1}^{N} \frac{M_{ij}}{M_i^{tot}}} \right] \quad (5.13)$$

Since $\sum_{j=1}^{N} \frac{M_{ij}}{M_i^{tot}} = 1$, we can thus write equation (5.13) as:

$$DII_i^M = \sum_{j=1}^{N} \frac{M_{ij}}{M_W} \left[\frac{\sum_{j=1}^{N} \frac{X_{ji}}{X_j^{tot}}}{\sum_{j=1}^{N} \frac{X_{ji}}{X_j^{tot}} + 1} \right] \quad (5.14)$$

In equation (5.14), we can see that DII_i^M comprises two ratios: (1) import of country *i*'s automobile in terms of the global import of automobile; (2) total automobile export of country *i*'s partner(s) to country *i* in terms of its partner(s)' total exports of automobiles, respectively divided by the aforesaid ratio plus one. The former ratio measures the strength of country *i*'s import of automobiles from its partner(s). Meanwhile, the second ratio measures the degree of dependency of country *i*'s partner(s) on country *i* as a market destination. In this respect, the higher the ratio the greater the dominating power of country *i* as a market destination. The minimum value of DII_i^M is zero which indicates that country *i* does not have any dominating power as a market destination. Moreover, as a market destination possessed by a country, dominating power increases when DII_i^M also increases.

5.4 Results

5.4.1 Global-level analysis

5.4.1.1 Binary network analysis (BNA)

Tables 5.6 and 5.7 respectively show the pattern of network for auto P&C and final automobile between 1990 and 2010 based on the binary network analysis. Columns 3-5 in Tables 5.6 and 5.7 depict the values of total node degree, average degree and connectedness degree. Based on Table 5.6, in general, the node degree, average degree and connectedness degree for auto P&C increased between 1990 and 2010. There are only 15 links of auto P&C for East Asian countries within the network in 1990 and 1995. In 2000, however, the number of links increased to 21 and then to 25 in 2010. At the same time, the values of connectedness also increased within that period. For instance, between 1990 and 2010, the degrees of connectedness increased from 10.4 percent to 17.4 percent.

Table 5.6: The Patterns of Nodes Degree, Average Degree, and Connectedness of Auto P&C Based on BNA between 1990 and 2010

Year	N	Total Node Degree $B(G)=\sum_{i=1}^{N}\sum_{j=1}^{N}a_{ij}$	Average Degree $\overline{B(G)}=\frac{B(G)}{N}$	Connectedness $BConn=\frac{B(G)}{N^2}$
1990	12	15	1.250	0.104
1995	12	15	1.250	0.104
2000	12	21	1.750	0.146
2005	12	24	2.000	0.167
2010	12	25	2.083	0.174

Based on results from Table 5.7, we can say that the value of node degree, average degree and connectedness degree for final automobiles increased until the year 2000 and then decreased slightly in the years that followed. Between 1990 and 2000, the

number of links for final automobiles increased from 20 to 26, while the connectedness degree increased from 13.9 percent to 18.1 percent. Since 2005, however, the number of links started to decline and fell to 22 in 2010, while the connectedness degree decreased from 18.1 percent to 15.5 percent in 2010. The decrease in the number of links after 2000 is due to the reduction in trade values of final automobiles between some countries; for example, trade between Japan and Thailand. In this respect, Thailand started to reduce its import of cars from Japan after that country (i.e. Thailand) emerged as the centre of production for Japanese cars.

Table 5.7: The Patterns of Nodes Degree, Average Degree, and Connectedness of Final Automobiles Based on BNA between 1990 and 2010

Year	N	Total Node Degree $B(G)=\sum_{i=1}^{N}\sum_{j=1}^{N}a_{ij}$	Average Degree $\overline{B(G)}=\frac{B(G)}{N}$	Connectedness $BConn=\frac{B(G)}{N^2}$
1990	12	20	1.667	0.139
1995	12	21	1.750	0.146
2000	12	26	2.167	0.181
2005	12	25	2.083	0.174
2010	12	22	1.833	0.153

5.4.1.2 Weighted network analysis (WNA)

Tables 5.8 and 5.9 measure the patterns of networks for East Asia's auto P&C and final automobiles respectively between 1990 and 2010 based on a weighted network analysis. Columns 3-5 in Table 5.8 depict the values of node strength, average strength, and weighted connectedness of auto P&C, while columns 3-5 in Table 5.9 present the node strength, average strength, and weighted connectedness of final automobiles.

In the case of auto P&C, results from the weighted analysis, as shown in Table 5.8, seem to be in tandem with the binary one. Based on Table 5.8, we can see that the node strength, average strength, and weighted strength increased consistently throughout the period under study. Between 1990 and 2010, the node strength went up from US$ 16.55 billion to US$ 74.10 billion, while the average strength and weighted connectedness increased from 1.380 to 6.175 and from 0.115 to 0.515 respectively. From both types of analysis above, we can conclude that not only does the number of links in the network of auto P&C expand, but so does the strength of the existence link (i.e., as represented by the summation of the export value of East Asia's auto P&C possessed by each existence links) over time. The increase in the number of links is due to the fact that a new country did not traditionally take part in the network, even though today it has actively taken part in the network.

Table 5.8: The Patterns of Nodes strength, Average strength, Weighted connectedness of Auto P&C Based on WNA between 1990 and 2010

Year	N	Node Strength $W(G)=\sum_{i=1}^{N}\sum_{j=1}^{N}w_{ij}$	Average Strength $\overline{W(G)}=\frac{W(G)}{N}$	Weighted Connectedness $WConn=\frac{W(G)}{N^2}$
1990	12	16.552	1.380	0.115
1995	12	22.165	1.847	0.154
2000	12	24.850	2.071	0.173
2005	12	42.297	3.525	0.294
2010	12	74.097	6.175	0.515

In the case of final automobiles, however, results from the weighted analysis are somewhat different from those of the binary one. Based on the third column in Table 5.9, it is obvious that the node strength increased consistently between 1990 and 2010. For instance, the node strength increased at an incredible pace from US$ 67.53 billion in 1990 to US$ 238.90 billion in 2010. During the same period, average

strength and weighted connectedness increased from 5.628 to 19.895 and from 0.469 to 1.658, respectively.

Table 5.9: The Patterns of Nodes Strength, Average Strength, and Weighted Connectedness of Final Automobiles Based on WNA between 1990 and 2010

Year	N	Node Strength $W(G)=\sum_{i=1}^{N}\sum_{j=1}^{N}w_{ij}$	Average Strength $\overline{W(G)}=\frac{W(G)}{N}$	Weighted Connectedness $WConn=\frac{W(G)}{N^2}$
1990	12	67.531	5.628	0.469
1995	12	75.278	6.273	0.523
2000	12	118.054	9.838	0.820
2005	12	200.614	16.718	1.393
2010	12	238.735	19.895	1.658

To sum up, from BNA and WNA, we can conclude that not only does the number of links in the network of auto P&C expand, but so does the strength of the existence link (i.e., as represented by the summation of the export value of East Asia's auto P&C possessed by each existence links) over time. The increase in the number of links is due to the fact that a new country did not traditionally take part in the network, even though today it has actively taken part in the network. Meanwhile, in the case of final automobiles, from both types of analysis above, we can conclude that IPNs expanded over time. This is because, although the number of links decreased slightly after 2000, the strength of those links continues to intensify after that period.

5.4.2 Country-specific analysis

5.4.2.1 Binary Analysis

Tables 5.10 and 5.11 depict the node degree centrality (NDC) and node density (ND) for auto P&C in nine East Asian countries between 1990 and 2010. As illustrated in Table 5.10, Japan has the highest NDC (i.e., the number of trade links) as well as ND for each year under study when compared to other East Asian countries in auto P&C. Based on that table, Japan has a network density of more than 35 percent for each year, and reached a network density of 50 percent in 2000 and 2005. These figures imply that in terms of auto P&C, Japan is the most integrated country in the East Asian region and remains the main actor in East Asia's automobile industry.[55] This phenomenon is due to the rapid growth of outsourcing activities relating to Japanese auto parts following relocation of production abroad which gathered pace in the 1990s (Schaede, 2009).

Table 5.10: The Patterns of East Asian Countries' NDC and ND for Auto P&C Based on Binary Analysis between 1990 and 2010

Country	1990		1995		2000		2005		2010	
	NDC_i	ND_i	NDC_i	ND_i	NDC_i	ND_i	NDC_i	ND_i	NDC_i	ND_i
CHI	1	0.045	4	0.182	5	0.227	6	0.273	6	0.273
IND	2	0.091	1	0.045	1	0.045	4	0.182	2	0.091
JPN	8	0.364	8	0.364	11	0.500	11	0.500	9	0.409
KOR	2	0.091	0	0	1	0.045	2	0.091	4	0.182
MAL	2	0.091	2	0.091	2	0.091	3	0.136	2	0.091
PHI	1	0.045	1	0.045	4	0.182	3	0.136	4	0.182
SIN	1	0.091	2	0.091	2	0.091	2	0.091	1	0.045
VN	0	0	0	0	2	0.091	3	0.136	3	0.136
THA	1	0.045	2	0.091	2	0.091	5	0.227	8	0.364

Note: The values of NDC_i and ND_i have been calculated using formulae $NDC_i = \sum_{j=1}^{N} a_{ij} + a_{ji}$ *and* $ND_i = \frac{NDC_i}{2(N-1)}$ *respectively*

[55]The main actors in the network are those with a high degree of centrality and are actively involved in relationships with other actors (countries), while the peripheries are those with a low degree of centrality and are less involved in relationships with other actors.

In addition, Table 5.10 suggests that China has become the second main actor in the auto P&C trade for she has the second largest value of NDC and ND between 1995 and 2005. However, in 2010 China's position was overtaken by Thailand. In 1995, China had a network density of 18.2 percent and this figure has increased steadily to more than 27 percent in 2005. The increase in China's integrated level is probably associated with the "open door" policy earlier adopted by that country.

Table 5.11: The Patterns of East Asian Countries' NDC and ND for Final Automobiles Based on Binary Analysis between 1990 and 2010

Country	1990		1995		2000		2005		2010	
	NDC_i	ND_i	NDC_i	ND_i	NDC_i	ND_i	NDC_i	ND_i	NDC_i	ND_i
CHI	4	0.182	2	0.091	2	0.091	2	0.091	3	0.136
IND	1	0.045	2	0.091	3	0.136	2	0.091	2	0.091
JPN	10	0.455	10	0.455	10	0.455	9	0.409	7	0.318
KOR	2	0.091	4	0.182	6	0.273	5	0.227	3	0.136
MAL	2	0.091	2	0.091	2	0.091	3	0.136	3	0.136
PHI	1	0.045	1	0.045	3	0.136	2	0.091	2	0.091
SIN	2	0.091	2	0.091	2	0.091	2	0.091	3	0.091
VN	1	0.045	3	0.136	2	0.091	2	0.091	3	0.136
THA	2	0.091	1	0.045	4	0.182	4	0.182	4	0.182

Note: The values of NDC and ND have been calculated using formulae $NDC_i = \sum_{j=1}^{N} a_{ij} + a_{ji}$ *and* $ND_i = \frac{NDC_i}{2(N-1)}$ *respectively*

In the case of final automobiles, Japan once again became the main actor as she posits more than 45 percent of network density in most of the year under study (see Table 5.11). Additionally, starting from 1995 the Republic of Korea follows Japan's footstep to become the second important actor in East Asia's automobile network with a network density of more than 20 percent between 2000 and 2005. Based on the values of NDC and ND in Table 5.11, Thailand has emerged as the third biggest actor in East Asia's automobile network with a density of more than 18 percent between 2000 and 2005. However, in 2010 Thailand became the second main actor. Based on the above findings, we can say that in East Asia's automobile network,

Japan and the Republic of Korea are the two powers that are competing with each other, while Thailand has emerged as one of Japan's wings in Southeast Asia.

5.4.2.2 Weighted analysis

Tables 5.12 and 5.13 present the values of node strength centrality (NSC) and ranks for East Asia's auto P&C and final automobiles respectively between 1990 and 2010. Based on Table 5.12, Japan has the highest NSC for each year under study when compared to other East Asian countries in auto P&C. In terms of ranking, Japan occupied the first place in each year under study, which is consistent with the findings in the binary analysis. Meanwhile, Table 5.12 also shows that China became the second main actor in the auto P&C trade for she has the second largest value of NSC and occupied the second place in the years 1990, 2000, 2005 and 2010. In addition, this table also indicates that Thailand is the third main actor in East Asia's auto P&C trade as it has the third largest value of NSC and ranked third in the years 1990, 2000 and 2005. Interestingly, this result can only be traced clearly using the weighted analysis. In fact, what has been achieved by Thailand's auto industry is closely associated with the active involvement of Japanese companies such as Toyota and Mitsubishi in that country.

Table 5.12: East Asia's NSC for Auto P&C Based on Weighted Analysis between 1990 and 2010

Country	1990		1995		2000		2005		2010	
	NSC_i	Rank	NSC_i	Rank	NSC_i	Rank	NSC_i	Rank	NSC_i	Rank
CHI	0.067	2	0.021	4	0.051	2	0.107	2	0.145	2
IND	0.020	4	0.024	3	0.012	4	0.013	6	0.013	5
JPN	0.278	1	0.314	1	0.285	1	0.218	1	0.164	1
KOR	0.017	5	0	8	0	9	0.019	4	0.066	3
MAL	0.008	7	0.016	5	0.009	5	0.015	5	0.011	6
PHI	0.003	8	0.006	7	0.007	6	0.008	7	0.006	7
SIN	0.011	6	0.009	6	0.006	7	0.004	8	0.003	9
VN	0	9	0	9	0.001	8	0.002	9	0.004	8
THA	0.022	3	0.042	2	0.018	3	0.040	3	0.047	4

Note: The value of NSC_i has been calculated using formula $NSC_i = \sum_{j=1}^{N} w_{ij} + w_{ji}$

Table 5.13: East Asia's NSC for Final Automobiles Based on Weighted Analysis between 1990 and 2010

Country	1990		1995		2000		2005		2010	
	NSC_i	Rank	NSC_i	Rank	NSC_i	Rank	NSC_i	Rank	NSC_i	Rank
CHI	0.003	6	0.008	5	0.004	5	0.009	4	0.047	3
IND	0.002	8	0.005	7	0.003	7	0.002	7	0.005	6
JPN	0.338	1	0.330	1	0.309	1	0.208	1	0.170	1
KOR	0.009	2	0.044	2	0.059	2	0.067	2	0.052	2
MAL	0.006	4	0.010	4	0.004	6	0.004	5	0.006	5
PHI	0.003	7	0.004	8	0.002	8	0.001	8	0.003	8
SIN	0.004	5	0.007	6	0.006	4	0.003	6	0.002	9
VN	0	9	0.002	9	0.001	9	0.001	9	0.003	7
THA	0.008	3	0.011	3	0.010	3	0.011	3	0.021	4

Note: The value of NSC_i has been calculated using formula $NSC_i = \sum_{j=1}^{N} w_{ij} + w_{ji}$

In the case of final automobiles, Japan as expected became the main actor as she had the highest score of NSC and consistently occupied the top rank for each year under study (see Table 5.13). The Republic of Korea seems to follow Japan's footstep to become the second main actor in East Asia's automobile networks for she had the second highest score of NSC and consistently occupied the second place for each year under study. In addition, based on the values of NSC and the rank given to each country in Table 5.11, Thailand has emerged as the third important player in East Asia's automobile networks for each year under study with the exception of the year 2010. The findings discussed above are consistent with those in the binary approach which also concluded that Japan and the Republic of Korea are the two most important powers in East Asia's automobile networks, while Thailand has emerged as a new but significant power in that network.

5.4.3 Network domination by country

5.4.3.1 Binary approach

Tables 5.14 and 5.15 present the values of DDI_i^X and DDI_i^M of auto P&C based on export and import analyses respectively, using a binary approach in nine East Asian countries between 1990 and 2010. From the export analysis (see Table 5.14), we can see that Japan has the highest dominating power as an exporter of auto P&C between 1990 and 2010 with a DDI_i^X of well over 0.6 in most of the years under study. Nevertheless, in terms of trend, Japanese domination seemed to have reached a peak in 2000 and then gradually declined in subsequent years. This implies that Japan is still one of the world's biggest suppliers of auto P&C as many countries in the world, particularly those in the Asian region, still rely on her as an auto P&C source, either for their local needs or for exports. The slight reduction in the DDI_i^X after 2000 does not mean that Japanese dominating power in the auto P&C had begun to fade. This is because findings in Chapter 4 have revealed that Japan has consistently occupied the top position between 1990 and 2010. Moreover, Japanese companies continue to dominate but not necessarily from Japan, such that probably something more complex is happening here. This is likely due to many Japanese auto parts manufacturers moving their operations abroad in order to supply components to Japanese automakers from their overseas affiliates.

Table 5.14: Domination Degree Index (DDI) for Auto P&C by Country and Year Based on Export Side Analysis Using Binary Approach

Country	1990	1995	2000	2005	2010
CHI	0	0	0	0.09	0
IND	0	0	0	0	0
JPN	0.647	0.647	0.671	0.647	0.477
KOR	0	0	0.091	0.182	0.091
MAL	0	0	0	0	0
PHI	0	0	0	0	0
SIN	0	0	0	0	0
VN	0	0	0	0	0
THA	0	0	0	0.068	0.364

Table 5.15: Domination Degree Index (DDI) for Auto P&C by Country and Year Based on Import Side Analysis Using Binary Approach

Country	1990	1995	2000	2005	2010
CHI	0	0	0	0	0.137
IND	0	0	0	0	0
JPN	0	0	0	0	0
KOR	0	0	0	0	0
MAL	0	0	0	0.119	0
PHI	0	0	0	0	0
SIN	0	0	0	0	0
VN	0	0	0	0	0
THA	0	0	0.091	0.091	0.091

Meanwhile, the decade 2000-2010 witnessed the Republic of Korea and Thailand beginning to exert more dominating power as exporters of auto P&C (see Table 5.14). In this respect, these two countries have begun to dominate the source of auto P&C. For the Republic of Korea, its dominating power is made apparent by the fact that countries such as Vietnam and China rely on her for their source of input of auto P&C. We also found that Thailand has begun to dominate exports of P&C in 2005 with a DDI_i^X value of 0.068, and in 2010 Thailand became the second auto P&C's dominator after Japan, followed by Korea with a DDI_i^X value of 0.364. From the import side of auto P&C, however, Thailand seems to have shown some consistent power of DDI_i^M at a value of 0.091 in 2000, 2005 and 2010. In this manner, Japan consistently relied on her as a major market of auto P&C in East Asia. Interestingly, in 2010, China began to exert dominating power in the import of P&C when Japan

starts to rely on her as an important export destination of auto P&C (cf. Table 5.15). This situation is likely a consequence of changes in the Chinese industrial policy where the tariff for imported auto parts was lowered to 10 percent after China joined the WTO in 2001 (Holweg et al. 2005).

Tables 5.16 and 5.17 illustrate the values of DDI_i^X and DDI_i^M for final automobiles based on export and import analyses respectively, using binary approach in nine East Asian countries between 1990 and 2010. As can be seen in Table 5.16, the export analysis indicates that Japan and the Republic of Korea have the most dominating power as exporters of final automobiles between 1990 and 2010, even though Japan is still far ahead of the Republic of Korea in terms of dominating power for each year under study. From these results, it is obvious that the dominating power of Japan as the world's leading car exporter is very significant even though this country has experienced severe economic problems such as the economic stagnation of the 1990s (i.e., after its stock market and property bubbles burst) and the global financial crisis that beset its economy in 2008/9. In other words, economic turmoil does not seem to have any significant impact on the rank of Japan's dominating power as a car exporter even though there appears to be a diminishing trend in the Japanese DDI_i^X after 2000. In the case of the Republic of Korea, the significant improvement in DDI_i^X during the period 2000-2010 indicates that Korean cars became popular particularly for Western customers due to the competitiveness in price of its small-size cars.

Table 5.16: Domination Degree Index (DDI) for Final Automobiles by Country and Year Based on Export Side Analysis Using Binary Approach

Country	1990	1995	2000	2005	2010
CHI	0	0	0	0	0.091
IND	0	0	0	0	0
JPN	0.682	0.682	0.682	0.573	0.496
KOR	0.091	0.091	0.273	0.182	0.091
MAL	0	0	0	0	0
PHI	0	0	0	0	0
SIN	0	0	0	0	0
VN	0	0	0	0	0
THA	0	0	0	0.182	0.273

Table 5.17: Domination Degree Index (DDI) for Final Automobiles by Country and Year Based on Import Side Analysis Using Binary Approach[56]

Country	1990	1995	2000	2005	2010
CHI	0	0	0	0	0
IND	0	0	0	0	0
JPN	0	0	0	0	0
KOR	0	0	0	0	0
MAL	0	0	0	0	0
PHI	0	0	0.090	0	0
SIN	0	0	0	0	0
VN	0	0	0	0	0
THA	0	0	0	0	0

In addition, after the year 2000, the dominating power of both Thailand and China as exporters of final automobiles seems to have grown. Also, these two countries seem to follow in the footsteps of Japan and the Republic of Korea, with Thailand slightly ahead of China. This phenomenon might be due to the active involvement of some Japanese automobile firms in both Thailand and China. The likely effect of such action is to have increased the dominating power of Thailand and China and in turn shifted the traditional dependency of other countries on Japan slightly towards these two countries. In other words, the increase in Thai and Chinese dominating powers after 2000 is probably due to a slight reduction in Japan's dominating power during the economic turmoil, wherein the dependency of other countries on Japan seems to have shifted towards these two countries.

[56]Tables 5.15 and 5.17 seem to have limited entries due to the use of 15 percent threshold. For this reason, we will conduct the above analysis using weighted approach in the following sub-section.

To sum up, the results from the binary analysis seem to divide East Asian countries into two groups: (1) countries that have dominating power in the automobile industry whether as an exporter, importer, or both (i.e., those that possess $DDI_i^X > 0$ and/or $DDI_i^M > 0$); (2) countries that do not have any dominating power in the automobile industry whether as an exporter, importer, or both (i.e., those that possess $DDI_i^X = 0$ and/or $DDI_i^M = 0$). Based on the above findings, the first group consists of Japan, Republic of Korea, Thailand, and China, while the second consists of Indonesia, Malaysia, the Philippines, Singapore, and Vietnam. The idea of this chapter is to provide indices that summarise the information revealed by the network diagrams in the previous chapter. As expected from this analysis (as well as from the network diagrams), Japan is consistently the biggest dominator in the East Asian region in terms of both auto P&C and final automobiles since many countries still rely on her for both auto P&C and final automobiles. Meanwhile, the rapid developments of the automobile industry in the Republic of Korea, Thailand and China have also given them some dominating power in the East Asian automobile network.

5.4.3.2 Weighted approach

Tables 5.18 and 5.19 below show the value of the domination intensity index (DII) for auto P&C based on export and import analyses respectively, using the weighted approach. Based on these tables, the results from using the weighted approach seem to generally support the previous findings from the binary approach. In the weighted approach, DII represents the strength of the interactions as mediated by each country. Despite the fact that two countries can have the same DDI when using the binary

approach, they can also be associated to slightly different DII. We hope that the two approaches can provide complimentary insights.

Table 5.18: Domination Intensity Index (DII) for Auto P&C by Country and Year Based on Export Side Analysis Using Weighted Approach

Country	1990	1995	2000	2005	2010
CHI	0.000	0.001	0.001	0.007	0.030
IND	0.000	0.000	0.000	0.001	0.001
JPN	0.126	0.142	0.100	0.094	0.097
KOR	0.000	0.001	0.004	0.010	0.019
MAL	0.000	0.000	0.000	0.000	0.000
PHI	0.000	0.000	0.000	0.000	0.001
SIN	0.000	0.000	0.000	0.000	0.000
VN	0.000	0.000	0.000	0.000	0.000
THA	0.000	0.000	0.001	0.004	0.008

Note: 0.000 indicates that the value is extremely small.

Table 5.19: Domination Intensity Index (DII) for Auto P&C by Country and Year Based on Import Side Analysis Using Weighted Approach

Country	1990	1995	2000	2005	2010
CHI	0.023	0.002	0.002	0.010	0.025
IND	0.001	0.002	0.001	0.001	0.003
JPN	0.000	0.000	0.000	0.000	0.000
KOR	0.000	0.000	0.000	0.000	0.000
MAL	0.002	0.002	0.001	0.002	0.002
PHI	0.000	0.000	0.001	0.000	0.001
SIN	0.003	0.004	0.000	0.001	0.001
VN	0.000	0.000	0.000	0.000	0.000
THA	0.004	0.008	0.003	0.006	0.011

Note: 0.000 indicates that the value is extremely small.

The highest score of DII_i^X for both auto P&C and final automobiles between 1990 and 2010 belongs to Japan, while the second highest went to the Republic of Korea between 1990 and 2005 (cf. Tables 5.18 and 5.20). Meanwhile, Chinese auto P&C's DII_i^X increased over time, namely from 0.001 in 1995 to 0.030 in 2010. In 2010, the position of the Republic of Korea as the second highest exporter of auto P&C has been overtaken by China. Between 2005 and 2010, Thailand emerged as the third and fourth highest DII_i^X for final automobiles and auto P&C, respectively. This result is consistent with DDI_i^X using the binary approach. However, in 2010 the result between these two approaches is slightly different in the case of auto P&C. For

example, the auto P&C's DII_i^X for China of 0.030 is the second highest after Japan, but this cannot be identified using the binary approach where its DDI_i^X is 0.00, as shown in Table 5.14.

As far as the import of auto P&C is concerned, we can see that Thailand posited the highest score of DII_i^M between 1995 and 2000. Its position, however, has been overtaken by China in 2005 and 2010, wherein Chinese auto P&C's DII_i^M increased dramatically in both years (cf. Table 5.19). In general, for Indonesia, Malaysia, Singapore and the Philippines, the scores of their auto P&C's DII_i^M are somewhat low and consistent throughout the year under study. In the case of import of final automobiles, scores of DII_i^M indicate that both Japan and the Republic of Korea did not have any dominating power as importers of final automobiles, while other East Asian countries had a lower score. Moreover, we also found that China has the highest dominating power as a final automobile market compared to other East Asian countries, but its DII_i^M is diminishing over time, i.e., from 0.018 in 1990 to 0.007 in 2010 (cf. Table 5.21)[57].

Table 5.20: Domination Intensity Index (DII) for Final Automobiles by Country and Year Based on Export Side Analysis Using Weighted Approach

Country	1990	1995	2000	2005	2010
CHI	0.000	0.000	0.000	0.000	0.002
IND	0.000	0.000	0.000	0.000	0.000
JPN	0.227	0.163	0.141	0.115	0.112
KOR	0.002	0.012	0.019	0.026	0.023
MAL	0.000	0.000	0.000	0.000	0.000
PHI	0.000	0.000	0.000	0.000	0.001
SIN	0.000	0.000	0.000	0.000	0.000
VN	0.000	0.000	0.000	0.000	0.000
THA	0.000	0.000	0.000	0.004	0.009

Note: 0.000 indicates that the value is extremely small.

[57] The values of DDI cannot be captured using binary approach (cf. Table 5.17)

Table 5.21: Domination Intensity Index (DII) for Final Automobiles by Country and Year Based on Import Side Analysis Using Weighted Approach

Country	1990	1995	2000	2005	2010
CHI	0.018	0.003	0.001	0.000	0.007
IND	0.000	0.000	0.000	0.001	0.003
JPN	0.000	0.000	0.000	0.000	0.000
KOR	0.000	0.000	0.000	0.000	0.000
MAL	0.001	0.003	0.000	0.001	0.001
PHI	0.000	0.000	0.000	0.000	0.001
SIN	0.001	0.001	0.000	0.001	0.000
VN	0.000	0.001	0.000	0.000	0.000
THA	0.000	0.002	0.000	0.001	0.002

Note: 0.000 indicates that the value is extremely small.

5.5 Conclusion

The broad aim of this chapter is to analyse the nature of East Asia's automobile network using social-network methods. Specifically, this chapter analysed the following: (1) the development of East Asia's automobile networks between 1990 and 2010; (2) the degree of integration among East Asian countries into the automobile networks; (3) identifying the main actor(s) in East Asia's automobile networks. In addition, in this chapter we have also developed a domination degree index (DDI) and domination intensity index (DII) to measure the dominating power of each East Asian country in the automobile networks.

The results suggested that the networks of East Asia's automobile industry are expanding over time both in terms of the number of links in the network as well as the strength of those links. This finding indicates that both export and import of automobile products in this region increase significantly over time. This development occurs probably because production (particularly parts and components) is increasingly being traded across national borders. In this respect, East Asian countries are becoming more tightly interconnected through trade flows regardless of

whether they are poor or rich, big or small economy, small (e.g. Singapore) or big (e.g. China) country.

In addition, as expected, Japan (which has consistently occupied the top position in IPNs) has emerged as the main player, both in the case of auto P&C and final automobiles. The Republic of Korea has also emerged as the second most important player in East Asia's final automobile networks, while China has become the second most important player in East Asia's auto P&C networks. Even though Thailand is the third most important player in East Asia's automobile networks in both auto P&C and final automobiles, the binary analysis of this chapter has suggested that there is a possibility for this country to overtake China and the Republic of Korea to become the second most important player in terms of both auto P&C and final automobiles. As discussed in the previous chapter, the dramatic changes in the development of Thailand's automobile industry as well as significant development in China's auto P&C have been made possible by the pivotal role played by Japan (on Thailand) and the Republic of Korea (on China) – all of which have stimulated the development of their subordinates' auto industry in a so-called "win-win situation".

In terms of the dominant power in East Asia's automobile networks, Japan has consistently been the most dominant power in the cases of both auto P&C and final automobiles, as many countries still rely on her for these products. Compared with other East Asian countries, Japan has strong economic fundamental since post-war and has experienced a spectacular economic growth particularly throughout the 1970s and most of the 1980s. After recovering from the so-called "bubble economy", the Japanese economy continues to grow, transforming the global economy and assisting with the economic development of many countries, particularly those in the

Asian region, through FDI. Japan also emerged as the leading automobile producer in the 1980s. This achievement was due to rises in Japanese export of automobiles to the rest of the world, the growth of automobile production in Japan itself, as well as the growth of Japanese automobile production abroad.

Meanwhile, the rapid developments in the automobile industry of the Republic of Korea since the 1980s, as well as those of Thailand and China in the 2000s, have also given them dominating power in East Asia's automobile network, albeit to varying degrees. For the Republic of Korea, its automobile industry became one of the priority industries in that country's Heavy and Chemical Industry Plan of 1973. The remarkable growth of this industry has placed South Korea as the world's eighth largest auto producer in 2008. In addition, Korean auto producer Hyundai already has production plants abroad in countries such as China, India, Czech Republic, United States, and Turkey, such that more than 40 percent of its production are now located abroad (Hyung, 2010). In the case of China, its automobile sector is growing very fast, and now China has become a components' producer with exports worldwide. Thailand has specialised in the production of pick-up trucks and passenger cars, exporting them to developed countries as well as ASEAN nations.

CHAPTER 6 : THE DETERMINANTS OF EAST ASIA'S AUTOMOBILE TRADE

6.1 Introduction

Over the last three decades, the East Asian region has experienced a massive expansion of IPNs which coincided with a significant change in the structure and nature of East Asia's trade networks. These changes are due to the action of foreign firms who extended the geographic coverage of their production activities and at the same time integrated their old stand-alone operations in individual host countries into complex IPNs (Ernst, 1997). These circumstances have led many researchers (such as Athukorala and Yamashita, 2006; Kimura, 2007; and Shepherd, 2010) to study the determinants of IPNs' development in East Asia. Nonetheless, it should be pointed out that in their empirical studies at least, those previous studies seem to neglect factors that are related to the structure and nature of IPNs. In addition, previous studies on the determinants of IPNs in automobile have given less attention to the role played by governments and Japanese MNCs.

The purpose of this chapter is to investigate empirically the factors that determine the level of automobile trade in East Asian countries by taking into account the recent changes in trade structure and nature of East Asia's automobile industry. To do so, in this chapter we include summary measures of the characteristic(s) of IPNs as well as government policies and Japanese FDI as additional explanatory variables in our augmented gravity models. In addition, our models also take into account the effect

of countries' position in the IPNs on trade of auto P&C and final automobiles. Based on this, our models differ from a previous conventional gravity model discussed in Section 6.2. This chapter is divided into eight sections that are structured as follows: Section 6.2 discusses some important issues related to the gravity model[58]. Section 6.3 discusses data description and sources. Sections 6.4 and 6.5 respectively discuss methodology and estimation framework. Sections 6.6 and 6.7 respectively discuss estimation results and regression results. Section 6.8 concludes the chapter.

6.2 The gravity model

In fact, the gravity model is derived from Newton's 1687 "Law of Universal Gravitation". This law in mechanics states that the gravitational force, F_{ij} (in newtons), between two objects is proportional to the product of each body's mass, M_1 and M_2 (in kg) divided by the square of the distance between their respective centres of gravity (in metres):

$$F_{ij} = G\frac{M_1 M_2}{D_{ij}^2} \tag{6.1}$$

Later on, in the 1860s, H. Carey first introduced this law into the study of human behaviour and since then the gravity model has been widely used in the social sciences (Cheng and Wall, 2005). In economics, the gravity model of international trade was first applied by Tinbergen (1962) and Pöyhönen (1963), and since then it has also been applied with much empirical success in the study of migration, tourism and investment.

[58]The gravity model has been widely used in empirical studies of international economics.

The gravitational law of trade can be expressed in much the same notation as model (6.1), except that M_i and M_j are redefined as the "economic mass" of the two countries. In this respect, "the trade flow between two countries is assumed to be proportional to the product of each country's 'economic mass' generally measured by GDP, each to the power of quantities to be determined, divided by the distance between the countries' respective 'economic centre of gravity', generally their capitals, raised to the power of another quantity to be determined" (Christie, 2002). The model can then be generalised as:

$$M_{ij} = K(GDP)_i^{\beta_1} (GDP)_j^{\beta_2} (Dis)_{ij}^{\beta_3} \qquad (6.2)$$

where:

M_{ij} : the amount of imports into country *i* from country *j*

GDP_i : country *i*'s GDP

GDP_j : country *j*'s GDP

Dis_{ij} : geographical distance between the two countries' capitals.

Model (6.2) can be expressed in linear form as follows:

$$\ln XM_{ij} = \alpha + \beta_1 \ln(GDP_i) + \beta_2 \ln(GDP_j) + \beta_3 \ln(Dis_{ij}) + \mu_{ij} \qquad (6.3)$$

where μ_{ij} is an additive disturbance term and α=ln(K). This baseline model gives relatively good results for the estimation. However, there are other factors that also influence trade levels. Linnemann (1966) developed an augmented gravity model by adding population as an additional measure of economic size. It is also common to use per capita income instead of population in the augmented gravity model to

capture the size effect; for example, Frankel and Wei (1998). A certain number of dummy variables that test for specific effects such as sharing a common border, speaking the same language, being a member of a trade agreement have also been added in most estimates of gravity models.

Criticism of the gravity model due to the absence of a theoretical background ended when a solid theoretical underpinning of the model was established by Anderson (1979) and Bergstrand (1985)[59]. Anderson (1979) was the first to provide a clear micro-foundation by building on Armington's assumption that products are differentiated by country of origin. In other words, this assumption stated that two products of the same kind but originating from different countries are imperfect substitutes in demand. Anderson's (1979) theoretical derivation of the gravity model developed gradually. Initially, he developed a simplest gravity model by assuming that there exist two countries, each of which produces one differentiated product. There is no tariff or transport cost. The model also assumes that both countries have identical Cobb-Douglas preferences. In this respect, the share of income spent on a tradable product is the same for both countries.

Anderson (1979) then strives for a more accurate representation of trade flows by relaxing the assumption of producing one differentiated product and allowing the two countries to produce tradable and non-tradable products. This modified model postulates an identical Cobb-Douglas or constant elasticity of substitution (CES) preference function for all countries as well as weakly separable utility functions between traded and non-traded goods. Here, utility maximisation with respect to income constraint gives traded goods shares that are a function of traded goods prices

[59]Since then, the theoretical studies on the gravity model have been continued by authors such as Helpman (1987), Bergstrand (1989), Deardorff (1998), and Anderson and Wincoop (2003).

only. Prices are constant in cross sections, so using the share relationships along with trade (im) balance identity, country *j*'s imports of country *i*'s goods are obtained. Then, assuming log linear functions in income and population for shares, the gravity model for aggregate imports is obtained.

In addition, Anderson (1979) also noted the endogeneity problem of income, and proposed two alternative solutions which follow the Instrumental Variable (IV) approach, employing different instruments as follows: (1) employing the lagged values of income as instruments; or (2) employing the first stage estimations of shares by OLS and substituting income values obtained from the estimated share for a second stage re-estimation of the gravity equation. For many goods, the aggregate gravity equation is obtained only by substituting a weighted average for the actual shares in the second shares. By using CES preferences over Armington-differentiated goods, Bergstrand (1985) derived a reduced-form equation for bilateral trade involving price indices. He then estimated the system in order to test the assumption of product differentiation using GDP deflators to approximate these price indices. For richness, the CES preferences were also nested with different elasticity substitution among imports and then between imports and domestic goods.

6.3 Data description and sources

The countries involved in this analysis are Japan, China, the Republic of Korea, Thailand, Indonesia, Malaysia, the Philippines, Singapore, and Vietnam, while their main trading partners other than the above countries are listed in Table 6.1[60]. Data for this analysis are taken from the years 1990 to 2010.

[60]Each pair of trading country (country *i* and its partner, i.e. country *j*) are included separately.

Table 6.1: List of Countries Chosen for the Empirical Studies

$Country_i$	$Country_j$	
China	Australia	Netherlands
Indonesia	Austria	New Zealand
Japan	Belgium	Norway
Republic of Korea	Brazil	Oman
Malaysia	Canada	Pakistan
Philippines	Chile	Panama
Thailand	China	Philippines
Vietnam	Denmark	Portugal
	Finland	Russian Federation
	France	Saudi Arabia
	Germany	Singapore
	Greece	South Africa
	India	Spain
	Indonesia	Sweden
	Ireland	Switzerland
	Israel	Thailand
	Italy	Turkey
	Japan	United Arab Emirates
	Rep. of Korea	United Kingdom
	Kuwait	United States
	Malaysia	Vietnam
	Mexico	

6.3.1 Trade data

Data for dependent variables (i.e. export of auto P&C, import of auto P&C, export of final automobiles, and import of final automobiles) in current US dollars have been acquired from the UN Comtrade. As described in Chapter 3, these data have been reconciled to overcome the problem of inconsistent data as reported by exporters and importers. In addition, we used SITC Revision 2 to classify the commodity group, and based on this classification the data have been divided into auto P&C and final automobiles. Commodities included under ‘auto P&C’ are chassis, bodies, and other parts and accessories, while commodities under ‘final automobiles’ comprise track-

laying tractors, wheeled tractors, passenger vehicles, goods-transport vehicles, special purpose vehicles, public service vehicles, and road tractors[61].

6.3.2 Gross domestic product (GDP_{it} and GDP_{jt})

In this study, we use the GDP of countries *i* and *j* as a proxy of economic size. Based on the modern trade theory, a country will trade with big economies rather than small ones. This is because big economies will typically have a greater variety of products and consumers. In addition, larger markets have a greater demand for foreign goods. Data for GDP_i and GDP_j (in current US dollars) have been obtained from the World Development Indicators (WDI). In this study, we expect a positive sign for the coefficients of both GDP_i and GDP_j. This is because the bigger country *i*'s GDP, the bigger the volume and variety of its national outputs, and the greater the scope of its exports. Likewise, the bigger country *j*'s GDP, the bigger the demand it can make for imports.

6.3.3 Geographical distance (Dis_{ij})

In this study, we use distance as a proxy of transport costs and other costs that are related to trade obstacles such as insurance, policy barriers, etc. The proximity measurement used in this study is the direct distance between capitals of the two countries (countries *i* and *j*) in kilometres. Data for distance were obtained from the CEPII database. We expect a negative sign for the coefficient of Dis_{ij}. This is because the closer the distance between partner countries, the more familiar they are with each other's tastes and preferences, and the higher their trade flows will be. In

[61]Detailed information have been provided in Chapter 3.

contrast, the bigger the distance between partner countries, the bigger the trade cost between them, and consequently the bigger the trade obstacle between them.

6.3.4 Per capita income (PCY_{it} and PCY_{jt})

Many studies that use the gravity approach incorporate the per capita income of exporting and importing countries when estimating the model[62]. In general, countries with a higher per capita income trade more as they have better quality transportation infrastructure (viz. roads, railways, ports, airports, etc.). In addition, imports of automobiles are income elastic due to greater demand from countries with higher living standards. It also suggested that as the per capita income between two countries becomes more similar, the more similar will be the demand structure between them. This means that two countries with similar per capita income will trade more amongst themselves. In this study, the values of per capita income have been calculated using the following formula:

$$PCY = \frac{GDP}{Population} \tag{6.4}$$

PCYs can be positive or negative. If a country enjoys the economies of scale effect with a higher per capita income, then the coefficient for PCY_i will be positive. In contrast, if a country exports less due to the absorption effect, then the coefficient of PCY_i will be negative. Similarly, if country *j* demands more of country *i*'s goods due to higher income, then the coefficient for PCY_j will be negative. On the other hand, due to the economies of scale effect on country *j*, if more goods are produced in country *j*, then the coefficient of PCY_j will be negative.

[62]For example, Frankel & Wei (1998) and Athukorala & Yamashita (2006).

6.3.5 Absolute different in per capita income ($\left|\Delta PCY_{ijt}\right|$)

The reason for including this variable in the model is to capture the differences in factor endowment between paired countries in explaining trade. Based on the H-O hypothesis, the larger the differences in the factor endowments between two countries, the larger will be the trade between them. In this respect, the sign of $\left|\Delta PCY_{ij}\right|$ would be positive if the H-O hypothesis holds. On the other hand, based on the Linder hypothesis, the demand structure will be similar to the similarities of per capita income. In other words, the more similar countries' per capita income becomes, the larger the bilateral trade between them. In this respect, the sign of $\left|\Delta PCY_{ijt}\right|$ would be negative if this hypothesis holds. In this chapter, we used the following formula to calculate the absolute differences in per capita income:

.

$$\left|\Delta PCY_{ijt}\right| = \left|PCY_{it} - PCY_{jt}\right| \tag{6.5}$$

6.3.6 Relative Labour Cost (RLC_{ij})

The use of relative labour cost as one explanatory variable in this study is based on the standard comparative advantage explanation of trade flows. Therefore, we expect the relative labour cost to be one of the major factors impacting IPNs. Relative labour cost (adjusted for exchange rate differential) is calculated based on the following formula:

$$RLC_{ij} = \frac{W_i}{W_j} E_{ij} \tag{6.6}$$

where:

W_i = manufacturing wage index for country *i* (1992=100).

W_j = manufacturing wage index for country *j* (1992=100).

E = nominal bilateral exchange rate expressed as the value of country *i*'s currency in terms of country *j*'s currency.

Data for the annual manufacturing wages are taken from the US Bureau of Economic Analysis (BEA), while data for the bilateral exchange rate are derived from bilateral US$ exchange rates of the International Financial Statistic at the IMF.

In the export model, we expect RLC_{ijt} to have a negative sign because an increase in country *i*'s relative labour cost would lead to deterioration in country *i*'s cost competitiveness. In contrast, in the import model, we expect RLC_{ijt} to have a positive sign. This is because a decrease in country *i*'s relative labour cost would mean an improvement in country *i*'s competitiveness.

6.3.7 Common language (LAN_{ij})

The common language variable is included in our model as we expect countries that speak the same language will trade more with each other. Moreover, Head (2003) argued that two countries that speak the same language trade twice to three times as much as pairs that do not share a common language. In this study, paired countries that share a common language will take a value of one, while those that do not share a common language will take a value of zero. Data for common language are obtained from the CEPII database. We expect LAN_{ij} to have a positive sign as there is a possibility that the use of the same language can facilitate trade by reducing

transaction costs and can lead to a better understanding of each other's culture and legal system.

6.3.8 Free trade agreement (FTA_{ijt})

Free trade agreements such as ASEAN, the EU and NAFTA have proliferated in the last 20 years, and have been widely used in the gravity model by many authors. According to Head (2003), FTAs on average could raise trade by about 50 percent. He also pointed out that recent studies have found that FTAs have increased trade between partners as much as three times. In this study, we include this variable to capture the implication of membership in such trade agreement. The dummy variable takes the value of one if both countries in a given pair belong to the same FTA, and zero otherwise. Table 6.2 shows the relationships between East Asian countries and their trading partners up to the year 2004. We expect FTA_{ijt} to have a positive sign as FTA tends to generate more trade among its members.

Table 6.2: FTAs (Signed and in Effect) in East Asia until 2004

Country	FTA	Year Implemented
Japan	Japan-Singapore Economic Agreement for a New-Age Partnership	2002
Rep. of Korea	Asia-Pacific Trade Agreement Korea -Chile Free Trade Agreement	1976 2004
China	PRC-Thailand Free Trade Agreement	2003
Singapore	ASEAN Free Trade Agreement Singapore-European Free Trade Association (EFTA) Free Trade Agreement Singapore-New Zealand Closer Economic Partnership Agreement Singapore-Japan Economic Agreement for a New-Age Partnership Singapore-Australia Free Trade Agreement Singapore-United States Free Trade Agreement	1993 2001 2001 2002 2003 2004
Philippines	ASEAN Free Trade Agreement	1993
Indonesia	ASEAN Free Trade Agreement	1993

Malaysia	ASEAN Free Trade Agreement	1993
Thailand	ASEAN Free Trade Agreement PRC-Thailand Free Trade Agreement	1993 2003
Vietnam	ASEAN Free Trade Agreement	1995

6.3.9 Dummy of import substitution industrialisation policy *(ISI_{it})*

The governments of East Asian countries have taken various measures through policies and legislation to shape and facilitate the development of their automobile industries. Some countries are still implementing inward-oriented strategies, while others have implemented outward-oriented strategy. There is also the case that a country may implement both strategies at the same time. Bruton (1989) defines ISI as a development strategy carried out by developing countries to achieve two goals: (1) to have some industrialisation experience from developed countries[63]; (2) to protect their domestic industries due to competition from imported products. Through this strategy, a country will replace imports of certain products with domestic products. This means that certain products that were previously imported will not be imported in the same amount.

In this chapter, we use the import intensity index (MII) calculated in Chapter 4 to represent ISI policy. We include ISI_{it} in the import models and we expect this variable to have a negative sign. This is because, when a country implements the ISI policy, the country becomes more competitive in producing automobile products, and consequently its imports would decrease.

[63]Proponents of the ISI strategy have argued that the contribution of that strategy to industrialisation is by means of "learning by doing" (Shafaedin and Pizarro, 2007).

6.3.10 Dummy of export orientation industrialisation policy (EOI_{it})

In general, EOI is an outward-oriented strategy of industrialisation whereby a country has its focus on production for the foreign market. According to Ballasa (1981), EOI is a development strategy whereby governments implement a less protectionist or interventionist policy. In this respect, the role of government under this strategy is more to do with carrying out promotional measures by giving subsidies to overcome various shortcomings that can thwart industries from accomplishing economies of scale (Karunaratne, 1980)[64]. In addition, the government also provides various facilities such as infrastructure facilities, financial and credit facilities, as well as training for labour.

To identify if a country is implementing the EOI policy within a certain period, we use an export intensity index (XII)[65]. In this chapter, we include EOI_{it} in the export models. We would expect EOI_{it} to have a positive sign because any government that implements this policy would be encouraging the industry to promote exports.

6.3.11 Dummy of country's position (TOP_{it} , MID_{it} and BOT_{it})

As discussed in Chapter 4, the position of East Asian countries in the IPNs has been identified and categorised as "top", "middle" and "bottom". In this chapter, we include both "middle" and "bottom" in our model, with "top" as a reference group. From the export side, we expect MID_{it} and BOT_{it} to have a negative sign, while from the import side, we expect MID_{it} and BOT_{it} to have a positive sign. This is because

[64]Annex Table 6.1 show automotive policies implemented in East Asian countries.
[65]XII=exports of both auto P&C and final automobiles / total trade in both auto P&C and final automobiles.

both “middle” and “bottom” countries would export (import) less (more) auto P&C and final automobiles compared to the “top” country.

6.3.12 Network density (ND_{it})

As defined in the previous chapter, network density is the actual links in terms of potential links in a network. Network density is included in our model to capture the effect of each country’s integrated degree in a network on export and import of auto P&C and final automobiles. This variable is necessary to include in those models as it will show us the benefit(s) of joining IPNs. We predict that the export and import of auto P&C and final automobiles between any two countries are expected to be positively related to the network density of those countries. In other words, the bigger the network density, the bigger will be the exports (imports). To test this hypothesis, we use the network density index generated in Chapter 5.

6.3.13 Domination intensity index ($DIIx_{it}$ and $DIIm_{it}$)

We add $DIIx_{it}$ to the export models and $DIIm_{it}$ to the import models to capture the effect of dominating power on both exports and imports of auto P&C and final automobiles. We predict that both $DIIx_{it}$ and $DIIm_{it}$ will have a positive sign due to the fact that a country which has a larger dominating power as an exporter (importer) would export (import) more to (from) its trading partner(s) compared to those with a smaller dominating power. For example, Japan (who has the largest dominating power as exporter of auto P&C) would export more auto P&C to its partners compared to those with a smaller dominating power as exporters of auto P&C. This is because Japan serves as the main supplier of auto P&C for its partner(s), and its

partner(s) rely on her as source of their auto P&C. Both $DIIx_{it}$ and $DIIm_{it}$ indices, which have been calculated in Chapter 5, will be used to test this hypothesis.

6.3.14 Japanese foreign direct investment (FDI_A_{it} and FDI_B_{it})

In many countries in East Asia, the automobile industry still relies heavily on foreign technology and capital, particularly from Japan. To capture the critical role of Japanese Multinational Corporations (MNCs) in the development of East Asia's automobile industry, we include the variable of Japanese FDI in our model. Data for outward Japanese FDI (in the transport sector) to individual East Asian countries have been obtained from the Ministry of Finance, Japan, which have been converted to US dollars before being used here.

In this study, we had to split data for FDI into two sets, i.e. FDI between 1990 and 2004 (FDI_A_{it}), and FDI between 2005 and 2010 (FDI_B_{it}). This is because the time series data for Japanese FDI outflows are inconsistent due to the action of the Japanese Finance Ministry of releasing BOP-based FDI to replace the old FDI statistics (FDIS) starting from 2005. FDIS and BOP-based FDI have been compiled by means of different compilation methodologies. In the case of FDIS, the data have been obtained from a compilation of figures reported by investors covering only investments over 100 million yen. In contrast, data for the BOP-based FDI have been obtained from financial transactions, and they are more comprehensive compared to those of FDIS. In addition, data in FDIS always have a positive value as they are generated from the total amount of reported investment by investors. On the other hand, data for the BOP-based FDI are compiled based on accounting rules and they can be recorded in negative values owing to withdrawal of investment. Due to these

differences, we have split both types of dataset into FDI_A_{it} and FDI_B_{it} in the analyses.

The sign of coefficient for Japanese FDI outflows to individual developing East Asian countries can either be positive or negative. A positive sign implies that an increase in Japanese FDI outflows to developing East Asian countries would cause Japanese export (import) of automobile products worldwide to increase, while a negative sign means that an increase in Japanese FDI outflows to developing East Asian countries would cause Japanese export (import) of automobile products worldwide to decline.

6.3.15 Developing East Asia (DEA) as the exporter (importer) of automobile product (*Ddea(x)_W* and *Ddea(m)_W*)

The automobile industry in DEA continues to grow rapidly, particularly in Thailand, and China. According to Shimokawa (2010), given its huge population, DEA has the potential to become the world's largest automobile market. The aim of including this variable in our export (import) models is to capture the role of DEA as the centre of production for Japanese auto P&C and final automobiles. For example, Thailand has emerged as the production hub of Japanese cars for export worldwide. At the same time, together with China, the Philippines, Malaysia, Indonesia, and Vietnam, Thailand has also served as the production hub for various types of Japanese auto P&C products for export purposes. For this reason, the role played by DEA countries in boosting intra-industry trade in this region is crucial.

In this study, countries categorised under DEA are Thailand, China, the Philippines, Malaysia, Indonesia, and Vietnam. This selection is based on the criterion of annual Gross National Income (GNI) per capita as provided by the World Bank (2013)[66]. Under this criterion, Japan, the Republic of Korea, and Singapore have been categorised under 'developed East Asian nations'. DEA will take a value of one if country *i* is characterised as developing East Asia, while developed East Asia will take a value of zero.

6.3.16 Interaction term between Japanese FDI outflow and DEA as the exporter (importer) of automobile products (*lFDIi$_{it}$*Ddea(x)_W* and *lFDI*Ddea(m)_W*)

We include these variables in our model to capture the effect of Japanese FDI outflows on the DEA's export (import) of both auto P&C and final automobiles. In this study, we interact *lFDI* with *Ddea(x)_W* in the export models and with *Ddea(m)_W* in the import models. A dummy for *Ddea(x)_W* and *Ddea(m)_W* will take a value of one if the country is developing East Asia (i.e. DEA) and the value of zero if the country is developed East Asia. By adding the coefficient *lFDI* (main effect) to the coefficient of interaction term, we get the interaction effect. The interaction effect can be positive or negative. A positive sign implies that increase in DEA's exports (imports) is more than the increase in Japanese exports (imports). On the other hand, a negative sign implies that increase in DEA's exports (imports) is less than the increase in Japanese exports (imports).

[66]According to the World Bank (2013), countries with GNI of US$ 11,905 or less are defined as DEA.

Table 6.3: Summary of the Data

Group	Variable/Proxy	Formulae	Source
Size	GDP_{it}	-	WDI
	GDP_{jt}	-	WDI
Trade Cost and other trade obstacles	DIS_{ij}	-	CEPII
Country's development	PCY_{it}	$PCY_i=GDP_{it}/POP_{it}$	Author's calculation. Data for population are taken from IFS, IMF
	PCY_{jt}	$PCY_{jt}=GDP_{jt}/POP_{jt}$	
	$\lvert\Delta PCY_{ij}\rvert$	$\lvert\Delta PCY_{ij}\rvert = \lvert PCY_i - PCY_j\rvert$	Author's calculation
Labour cost effect	RLC_{ijt}	$RLC_{ij} = \frac{W_i}{W_j} E_{ij}$	US Bureau of Economic Analysis (BEA) and IFS.
Language effect	LANij	1 if the two countries share the common language; 0 otherwise	World Factbook
Trade agreement effect	FTA_{ijt}	1 if there is an FTA between country *i* and *j*; 0 otherwise	ADB
The ISI policy effect	ISI_{it}	1 if country *i* implementing ISI policy; 0 otherwise	Various sources
The EOI policy effect	EOI_{it}	1 if country *i* implementing EOI policy; 0 otherwise	Various sources
Country's position in IPNs	TOP_{it}	1 if country *i* occupied the top position; 0 otherwise	Author's calculation
	MID_{it}	1 if country *i* occupied the middle position; 0 otherwise	
	BOT_{it}	1 if country *i* occupied the bottom position; 0 otherwise	
Country's integrated degree	ND_{it}	refer equation 5.8	
Country's domination degree	DII_{it}	refer equations 5.11-5.14	
The role of MNE's	FDI_{it}	-	Ministry of Finance, Japan

6.4 Methodology

Traditionally, cross-section data has been used to estimate trade relationships in a gravity model. However, a panel data methodology is now used widely due to some disadvantages of using cross-sectional data. For example, the cross-sectional model is unable to control for unobserved invariant heterogeneity, and it then generates biased results. The panel data methodology can solve the problem of heterogeneity by allowing for individual and year-specific effects. In addition, unobserved trading-partner-pairs' individual effects can be monitored when using panel data. In this study, we use the panel data analysis approach for our empirical gravity models.

Using our dataset, we estimate four gravity models for East Asia: (1) the gravity model of East Asia's export of auto P&C, (2) the gravity model of East Asia's import of auto P&C, (3) the gravity model of East Asia's export of final automobiles, and (4) the gravity model of East Asia's import of final automobiles. The initial step is to regress to the basic specification model as shown below.

$$ln\,XM_{ijt} = \alpha + \beta_1\, ln(GDP_{it}) + \beta_2\, ln(GDP_{jt}) + \beta_3\, ln(Dis_{ijt}) + v_{1ij} \qquad (6.7)$$

where:

XM_{ijt} : bilateral trade (export or import) between country *i* and country *j*

GDP_{it} : country *i*'s GDP

GDP_{jt} : country *j*'s GDP

Dis_{ij} : geographical distance between the two countries' capitals.

υ_{1ijt} : error term

The second step is to extend the basic specification model by adding the country's development variables (i.e. per capita income and absolute difference in per capita income), relative labour cost as well as the dummies of common language and free trade agreement as shown in equation (6.8). Common border is not included in our augmented specification model as trade is by sea.

$$\begin{aligned} \ln XM_{ijt} &= \alpha + \beta_1 lGDP_{it} + \beta_2 lGDP_{jt} + \beta_3 lDis_{ij} + \beta_4 lPCY_{it} + \beta_5 lPCY_{jt} \\ &\quad + \beta_6 \ln\left|\Delta PCY_{ijt}\right| + \beta_7 lRLC_{ijt} + \beta_8 LAN_{ij} + \beta_9 FTA_{ijt} + \upsilon_{2ijt} \end{aligned} \tag{6.8}$$

where;

PCY_{it} : income per capita of exporting country *i*.

PCY_{jt} : income per capita of importing country *j*.

$\left|\Delta PCY_{ijt}\right|$: absolute difference in income per capita between *i* and *j*

LAN_{ij} : dummy of common language

RLC_{ijt} : Relative labour cost of country *i*

FTA_{ijt} : dummy of free trade agreement

υ_{2ijt} : error term

and the rest of the variables and parameter symbols are defined as in equation (6.6).

In developing model (6.8) above, we followed the specification in Athukorala and Yamashita (2006). The contribution of this study starts in the third step where we add: (i) the dummies of ISI and EOI policies to our model to highlight the effect of those policies on East Asia's automotive industries; (ii) the dummies of top, middle and bottom to take into account the position of each country in the IPNs; (iii) the node density and domination intensity index to capture the effect of each country's integrated degree and domination degree, respectively; (iv) the Japanese FDI variable as well as interactive variables to capture the role of Multinational Corporations

(MNCs). Due to the inconsistency in the time series data of Japanese FDI outflows[67], we split data for FDI outflows into FDI_A (i.e., FDI between 1990 and 2004) and FDI_B (i.e., FDI between 2005 and 2010) in the following models. Thus, the gravity model of exports became:

$$\begin{aligned}\ln X_{ijt} &= \alpha + \beta_1 lGDP_{it} + \beta_2 lGDP_{jt} + \beta_3 lDis_{ij} + \beta_4 lPCY_{it} + \beta_5 lPCY_{jt} \\ &+ \beta_6 l\left|\Delta PCY_{ijt}\right| + \beta_7 lRLC_{ijt} + \beta_8 LAN_{ij} + \beta_9 FTA_{ijt} + \beta_{10} MID_{it} \\ &+ \beta_{11} BOT_{it} + \beta_{12} ND_{it} + \beta_{13} lDIIx_{it} + \beta_{14} EOI_{it} + \beta_{15} lFDI\_A_{it} \\ &+ \beta_{16} lFDI\_A_{it} * Ddea(x)\_W + \beta_{17} lFD\_B_{it} \\ &+ \beta_{18} lFDI\_B_{it} * Ddea(x)\_W + \beta_{19} Ddea(x)\_W + \beta_{20} T + \upsilon_{3ijt}\end{aligned} \tag{6.9}$$

where,

MID_{it} : dummy for middle position

BOT_{it} : dummy for bottom position

ND_{it} : node density

$DIIx_{it}$: domination intensity index for exporter

EOI_{it} : dummy for EOI policy

FDI_A_{it} : Japanese FDI outflow in automotive industry to country *i* between 1990 and 2004

FDI_B_{it} : Japanese FDI outflow in automotive industry to country *i* between 2005 and 2010

$Ddea(x)\_W$: dummy of DEA as the exporting country

$lFDI\_A_{it} * Ddea(x)\_W$: interaction term for FDI_A in export model

$lFDI\_B_{it} * Ddea(x)\_W$: interaction term for FDI_B in export model

T : time effects

υ_{3ijt} : error term

[67]Refer to Section 6.3.14.

while the gravity model for the import models became:

$$\begin{aligned}\ln M_{ijt} &= \alpha + \beta_1 lGDP_{it} + \beta_2 lGDP_{jt} + \beta_3 lDis_{ij} + \beta_4 lPCY_{it} + \beta_5 lPCY_{jt} \\ &+ \beta_6 l\left|\Delta PCY_{ijt}\right| + \beta_7 RLC_{ijt} + \beta_8 LAN_{ij} + \beta_9 FTA_{ijt} + \beta_{10} MID_{it} \\ &+ \beta_{11} BOT_{it} + \beta_{12} ND_{it} + \beta_{13} lDI\,\mathrm{Im}_{it} + \beta_{14} ISI_{it} + \beta_{15} lFDI\_A_{it} \\ &+ \beta_{16} lFDI\_A_{it} * Ddea(m)\_W + \beta_{17} lFD\_B_{it} \\ &+ \beta_{18} lFDI\_B_{it} * Ddea(m)\_W + \beta_{19} Ddea(m)\_W + \beta_{20} T + \upsilon_{4ijt}\end{aligned} \qquad (6.10)$$

where,

$DIIm_{it}$: domination intensity index for importer

ISI_{it} : dummy for ISI policy

$Ddea(m)\_W$: dummy of DEA as the importing country

$lFDI\_A_{it} * Ddea(m)\_W$: interaction term for FDI_A in imports model

$lFDI\_B_{it} * Ddea(m)\_W$: interaction term for FDI_B in imports model

υ_{4ijt} : error term

and the rest of the variables and parameter symbols are defined as in the above equations.

6.5 Estimation Framework

In this study, we faced the problem of zero trade flows when estimating our panel data. To overcome that problem, we took the approach of discarding the zero trade values from the sample. This approach is appropriate because these zero values would be undefined when we make our estimate using a log-linear model. In order to identify the presence of heteroscedasticity in our models, we used the Breusch-Pagan test. At the same time, we used variance inflation factor (VIF) and tolerance to identify the presence of multicollinearity. A VIF of 10 and above or a tolerance less

than 0.10 indicates a multicollinearity problem. Our model was estimated using the Least Squares Dummy Variable (LSDV) where country dummies are used to capture country-specific fixed effects, and time dummies (T) are used to capture time-specific effects. By adding country effects and time effects to the model, we can mitigate the possibility of endogeneity bias (Wooldrige, 2002). In addition, we choose the LSDV rather than the "within" estimator because our data contain time-invariant variables such as distance, dummy of language and dummies of countries' position in IPNs which would be dropped when regressing using the "within" estimator.

6.6 Regression Results and Discussion

The determinants of automobile trade between East Asian countries and their trading partners were estimated using three specifications of gravity equations in four different models. The regression results are presented in Tables 6.4 through 6.6. Tables 6.4 and 6.5 present the results of the basic specification gravity (equation 6.7) and augmented traditional gravity specifications (equation 6.8), estimated with the pooled OLS; while Table 6.6 gives the results for the augmented gravity specification estimated with LSDV. In each table, the results for the export models of auto P&C and final automobiles are reported in the second and fourth columns respectively, while results for the import models of auto P&C and final automobiles are reported in the third and fifth columns respectively. In each model, we used a robust standard error due to the presence of heteroscedasticity and autocorrelation problems. With R-squared above 0.50 in each model, the gravity models explain more than half of the bilateral exports and imports of both auto P&C and final automobiles.

6.6.1 Basic Specification Gravity Model (OLS)

As stated in equation 6.7, the basic specification gravity model has three explanatory variables, namely, country *i*'s GDP, country *j*'s GDP, and distance. As mentioned earlier, this model is estimated using pooled OLS, and we use robust standard error due to the presence of heteroscedasticity and autocorrelation problems. Based on Table 6.4, we can see that generally almost all explanatory variables are significant at least at the 1 percent level with the expected sign. Specifically, results for each explanatory variable will be discussed in the following.

The results show that market-size variables (i.e., GDP_{it} and GDP_{jt}) have a positive and significant association with exports and imports for both auto P&C and final automobiles, as predicted by the theory. This means that trade in auto P&C and final automobiles between East Asian countries and their trading partners could rise significantly if both parties experience strong economic growth. Interestingly, the coefficients of GDPs between exports and imports as well as between auto P&C and final automobiles, however, seem heterogeneous. As can be seen in Tables 6.4, the magnitudes of GDP_i in the export models are slightly greater than those in the import models. On the other hand, the magnitudes of GDP_j in the import models are slightly greater than those in the export models. This implies that export of both auto P&C and final automobiles depends more on the market size of the exporting country, while import of both products depends more on the market size of the importing country (i.e. their partner(s)). Therefore, we can say that larger economies such as Japan and the Republic of Korea tend to export auto P&C and/or final automobiles to smaller economies such as Thailand, the Philippines and Vietnam more than they import from them. At the same time, smaller economies tend to import more auto

P&C and/or final automobiles from larger economies than they export to them, and this indicates that smaller economies may be struggling to support their domestic automobile industry.

As expected, distance has a negative and significant effect on export and import for both auto P&C and final automobile models. This means that transport and transaction costs are an important determinant of trade flow, and East Asian countries trade less with countries that are far away from them. Therefore, any policy that reduces trade costs will enhance trade of auto P&C and final automobiles. As seen in Tables 6.4, the coefficients of distance are larger in the case of auto P&C compared to final automobiles. The differences are due to a greater sensitivity to costs in the production process as reflected in the local nature of production networks compared to the global market for final automobiles.

Table 6.4: Basic Specification Estimated by OLS for 1990 to 2010

Explanatory Variables	Auto P&C		Final Automobiles	
	Log of exports	Log of imports	Log of exports	Log of imports
Constant	-28.653***	-23.718***	-23.684***	-24.900***
$lGDP_{it}$	1.337***	0.553***	1.506***	0.311***
$lGDP_{jt}$	0.752***	1.490***	0.020	1.488***
$lDis_{ij}$	-1.373***	-1.880***	-0.196***	-0.978***
No of Obs.	5530	4931	3863	3779
R^2	0.525	0.456	0.328	0.383
Adjusted R^2	0.524	0.455	0.327	0.382
F	2035.54***	476.80***	889.94***	964.67***
RMSE	2.065	2.386	2.983	2.392

*Notes: ***, ** and * denote as significance at 1 percent, 5 percent and 10 percent respectively.*

6.6.2 Augmented traditional specification gravity model (OLS)

In the augmented traditional specification gravity model, we add variables such as per capita income (i.e. $lPCY_{it}$ and $lPCY_{jt}$), relative labour (RLC_{ijt}), cost common language (i.e. LNG_{ij}) and free trade agreement (i.e. FTA_{ijt}) to the previous basic gravity model. As with the previous basic gravity model, this augmented traditional model is also estimated using pooled OLS with robust standard error due to the presence of heteroscedasticity and autocorrelation problems. As can be seen in Table 6.5, the effects of market size and distance variables on export and import models in both auto P&C and final automobile are somewhat consistent with results from the basic specification gravity model even though $lPCY_{it}$, $lPCY_{jt}$, RLC_{ijt} , LNG_{ij} and FTA_{ijt} are included in the models.

Based on the results in Table 6.5, per capita income seems to be important variables. In the case of auto P&C, per capita income may represent superior transportation and communication infrastructure such as better ports, road, airports, telephone lines, internet access, etc. (Head, 2003). Meanwhile, in the case of final automobiles, per capita income may represent the purchasing power of consumers and sophistication of consumer tastes in richer countries, hence the imports of global brands instead of the local model. Based on the results, per capita income in both country *i* and country *j* has a positive sign and is significant at least at the 5 percent level in almost all models. This indicates that an increase in transportation and communication quality in county *i* and its partners as well as an increase in the purchasing power and sophistication of consumer tastes in richer countries could facilitate trade in auto P&C and final automobiles between countries under study. The coefficients on absolute differences in per capita income are significant statistically in almost all

models with negative sign, and these results support the Linder hypothesis. This hypothesis says that countries with similar factor endowments will trade more with each other compared to countries with dissimilar demands. Therefore, these results suggest that trade in auto products between developed economies (such as between Japan and the United States) would be greater than trade in those same products between developed and least developed economies (such as between Japan and Vietnam). Accordingly, the negative sign of the coefficient of absolute differences in per capita income also suggests that horizontal intra-industry trade (where goods are differentiated by attributes) between developed economies seems to account for much of the trade in automobile products compared to vertical intra-industry trade (where goods are differentiated by quality) between developed and developing economies.

The coefficients of RLC_{ijt} are statistically highly significant with the expected sign in both export and import models for both auto P&C and final automobiles. These results suggest that relative labour cost differentials are among the important factors behind cross border trade for both products. In addition, the size of coefficients of RLC_{ijt} is somewhat similar in all models. This might indicate that there exists an interconnectedness between import and export of auto P&C as well asa certain dependence of export of final automobiles on import of auto P&C.

The results also show that the coefficients of common language are significant statistically and have the anticipated positive sign in both export and import models for auto P&C and final automobiles. This result indicates that the use of a common language can facilitate trade. Meanwhile, coefficients of FTA have a positive sign and are significant statistically in the export and import models of auto P&C and

final automobiles (cf. Table 6.5). This indicates that bilateral trade between East Asian countries and their partners increases when both are members of an FTA. The estimated coefficients for the export and import of auto P&C are 0.995 and 1.224, respectively. This means that export and import flows of auto P&C with a member of a particular FTA are respectively more than two times and three times as much as those with a non-member.[68] In the case of final automobiles, the estimated coefficients for export and import are 0.505 and 0.458, respectively. This means that trade flows of final automobiles with a member of a particular FTA almost double as much as those with a non-member. These results also indicate that FTA stimulates more trade in auto P&C compared to trade in final automobiles.

Table 6.5: Augmented Traditional Specification Estimated by OLS for 1990-2010

Explanatory Variables	Auto P&C		Final Automobiles	
	Log of exports	Log of imports	Log of exports	Log of imports
Constant	-32.801***	-28.222***	-15.978***	-23.132***
$lGDP_{it}$	1.215***	0.468***	0.945***	0.305***
$lGDP_{jt}$	0.803***	1.533***	0.012	1.403***
$lDis_{ij}$	-0.923***	-1.422***	-0.404***	-1.291***
$lPCY_{it}$	0.351***	0.273***	1.134***	0.087***
$lPCY_{jt}$	-0.197***	0.052	0.273***	0.630***
$\lvert\Delta PCY_{ijt}\rvert$	0.072***	-0.052	-0.215***	-0.367***
$lRLC_{it}$	-0.345***	0.576***	-0.401***	0.438***
LNG_{ij}	0.540***	0.324***	1.475***	0.106*
FTA_{ijt}	0.995***	1.224***	0.505**	0.458*
No of Obs.	5530	4931	3863	3779
R^2	0.568	0.482	0.484	0.424
Adjusted R^2	0.567	0.481	0.482	0.423
F	1012.58***	332.53***	651.77***	301.17***
RMSE	1.768	2.311	2.655	2.288

*Notes: ***, ** and * denote as significance at 1 percent, 5 percent and 10 percent respectively.*

[68]exp (0.995) = 2.705 and exp (1.224) = 3.327.

6.6.3 Augmented gravity specification model (LSDV)

The augmented gravity specification model is generated by adding the countries' position variables (i.e., MID_{it}, and BOT_{it})[69], government policies variables (i.e., ISI_{it} and EOI_{it}), network density (i.e., ND_{it}), domination intensity index (i.e., $DIIx_{it}$ and $DIIm_{ix}$), foreign direct investment (i.e., FDI_{it}_A and FDI_{it}_B), and developing East Asia (i.e., Ddea(x)_W and Ddea(m)_W) to the previous augmented traditional model. As mentioned earlier, this model was estimated using the Least Square Dummy Variable (LSDV) where country and time dummies are used to capture country-specific and time-specific effects, respectively.

Based on results in Table 6.6, we can see that the effects of market size, distance, per capita income, absolute differences in per capita income, relative labour cost, common language and free trade agreement variables on export and import models in both auto P&C and final automobiles have not changed much if we compare them with the results in the augmented traditional gravity model in Table 6.5 (after other variables such as countries' position in IPNs, government policies, network density, domination intensity index, foreign direct investment, and DEA are included in the augmented gravity model).

As expected, the IPNs' structure (which is proxies by the position of East Asian countries in the automobile production chain) seems to be an important determinant in the development of a country's automobile trade. This is because we have found that a country's position dummy has an expected sign and statistically significant at least at the 5 percent level in all models. Based on Table 6.6, the export of auto P&C

[69]Top countries as a reference category.

and final automobiles by “middle” and “bottom” countries is less than the export of both products by a “top” country. The estimated coefficients of “middle” for the export of P&C and final automobiles are -0.198 and -1.925, respectively. These figures imply that exports of such products are well over half and five times smaller than that of the export by “top” countries, respectively. Meanwhile, in the case of “bottom” countries, the coefficients of export of both auto P&C and final automobiles are -0.794 and -2.539, respectively. This indicates that exports of such products are respectively well over two-fold and six-fold smaller than the exports of such products by “top” countries.

On the other hand, Table 6.6 shows that the imports of auto P&C and final automobiles for both “middle” and “bottom” countries are greater than imports by “top” countries of both products. The estimated coefficients of “middle” for the import of auto P&C and final automobiles are 0.499 and 0.445, respectively. This indicates that the imports of auto P&C and final automobiles by a “middle” country were respectively well over 1.3 times and 1.2 times greater than the import of the same products by “top” countries. Meanwhile, the coefficients of import of auto P&C and final automobiles for “bottom” countries were 0.343 and 1.183, respectively. This means that imports of both products were respectively doubled and tripled the imports by “top” countries of auto P&C and final automobiles.

The above findings provide us with relevant information about the strength of the role(s) played by a group of countries based on their position in IPNs. For example, in the case of “middle” countries, their roles as exporter of both auto P&C and final automobiles were greater compared to “bottom” countries but less than the “top” countries, while their roles as importer of auto P&C were greater compared to both

Table 6.6: Augmented Specification Estimated by LSDV for 1990-2010

Explanatory Variables	Auto P&C		Final Automobiles	
	Log of exports	**Log of imports**	**Log of exports**	**Log of imports**
Constant	13.602*	-29.821***	-14.801*	-35.054***
$lGDP_{it}$	0.441***	0.387***	0.303*	0.442***
$lGDP_{jt}$	0.810***	1.579***	0.084***	1.460***
$lDis_{ij}$	-0.959***	-1.350***	-0.483**	-1.278***
$lPCY_{it}$	0.171***	0.345***	0.260***	0.157***
$lPCY_{jt}$	-0.186***	0.006	0.260***	0.671***
$\lvert\Delta PCY_{ijt}\rvert$	0.033	-0.035	-0.211***	-0.341***
$lRLC_{it}$	-0.191***	0.331***	-0.216***	0.294***
LNG_{ij}	0.772***	0.359***	-0.096	-0.263***
FTA_{ijt}	0.902***	1.595***	0.532***	0.424***
MID_{it}	-0.198***	0.499*	-1.925***	0.445***
BOT_{it}	-0.794***	0.343**	-2.539***	1.183**
EOI_{it}	0.302**	-	0.391***	-
ISI_{it}	-	0.302	-	-0.348***
ND_{it}	0.992***	1.543**	3.321***	-0.766
$LDIIx_{it}$	0.402***	-	0.308***	-
$LDIIm_{it}$	-	0.468***	-	0.374***
$lFDI\_A_{it}$	-0.229**	0.066	0.216	0.352
$lFDI\_A_{it}$*Ddea(x)_W	0.237**	-	-0.072	-
$lFDI\_A_{it}$*Ddea(m)_W	-	-0.054	-	-0.346
$lFDI\_B_{it}$	-0.209*	0.189	0.573	0.357
$lFDI\_B_{it}$*Ddea(x)_W	0.211**	-	-0.083	-
$lFDI\_B_{it}$*Ddea(m)_W	-	-0.177	-	-0.326
Country Dummies				
Ddea(x)_W	-4.046**	-	1.521	-
Ddea(m)_W	-	1.921	-	5.279
Time Dummies	YES	YES	YES	YES
No of Obs.	5472	4931	3863	3779
R^2	0.634	0.518	0.650	0.505
Adjusted R^2	0.632	0.516	0.649	0.503
F	154.46	67.28***	193.86***	86.21***
RMSE	1.810	2.268	2.153	2.231

*Notes: ***, ** and * denote as significance at 1 percent, 5 percent and 10 percent respectively.*

"bottom" and "top" countries. Meanwhile, their role as importer of final automobiles was smaller than the "bottom" countries but greater than the "top" countries. Interestingly, it is obvious that the roles of "middle" countries as exporter of auto P&C were slightly smaller compared to the "top" countries, while the roles of the "bottom" countries as exporter of final automobiles were much smaller compared to the "top" countries.

The nature of IPNs, which are proxies by network density and domination intensity indices, is also an important determinant of a country's automobile trade. Network density represents a country's degree of integration in a network. Based on Table 6.6, we found that network density for country *i* has a positive sign and is significant at least at the 5 percent level in almost all models. This indicates that the more a country is integrated in the network, the more it trades with other countries in that network. In terms of auto P&C, a one-unit increase in a country's degree of integration has led to an increase in both exports and imports of more than double. Meanwhile, the increase of one unit in a country's integrated level has led to an increase in the export of final automobiles by nine-fold. This result indicates that the country with the highest integrated degree in IPNs stands to benefit more from its exports of final automobiles compared to trade in auto P&C.

The dominating power of a country as an exporter of auto P&C and final automobiles is represented by the value of *DIIx*, while the dominating power of a country as an importer of auto P&C and final automobiles is represented by *DIIm.* Based on Table 6.6, we found that *DIIx* and *DIIm* for country *i* have a positive sign and are significant at the 1 percent level in all models. An increase of 1 percent in the export dominating power of both auto P&C and final automobiles has led to an

increase of 0.40 percent and 0.31 percent in exports of both products, respectively. Meanwhile, a 1 percent increase in the import dominating power of both auto P&C and final automobiles has led to an increase by 0.47 percent and 0.37 percent in imports of both products, respectively.

As we expected in the previous chapter, government policies and programmes, which are proxies by ISI and EOI policies, seem to be an important determinant in the development of a country's automobile trade. Based on the results, ISI policies produce the expected negative effect on the imports of final automobiles (cf. Table 6.6). These results imply that ISI development strategy decreases imports of East Asia's final automobiles. Nevertheless, there is no statistical evidence that shows the effect of this strategy on the imports of auto P&C. In addition, results in Table 6.6 also indicate that EOI policies affect the exports of auto P&C and final automobiles positively. This means that EOI strategy stimulates exports of East Asia's auto P&C and final automobiles. Based on these results, one can conclude that government measures in support of the automotive industry, such as reducing tariff rates, providing subsidised loans, tax exemptions and expanding infrastructure and industrial estates, have managed to develop that industry and thus increase exports.

Specifically, results in Table 6.6 indicate the following. First, ISI policies implemented by East Asian countries have reduced their import of final automobiles almost by double [exp (0.348) = 0.950]. Second, EOI policies towards East Asia's auto industry have managed to increase the exports of auto parts, components and automobiles in that region. In the case of final automobiles, EOI policies have led to an increase in East Asia's exports by as much as double [exp (0.391)= 1.063], while for auto P&C, EOI policies have contributed to an increase in exports by more than

50 percent [exp (0.302) = 0.821]. This finding seems to suggest that EOI policies implemented by many East Asian countries facilitating FDI into those countries and consequently increase exports. For example, in the case of Thailand, EOI policies and industrialisation strategies have led to the expansion of Japanese FDI in the automotive sector of that country[70]. This, in turn, has led to the increase in the export of auto P&C from Japan to Thailand (Asia Monitor Resource Centre, 2011).

Even though countries' strategies towards developing their automobile industry in this region vary from one country to another, it is obvious that governmental policies are crucial to ensuring that East Asia's automobile industry achieves competitiveness and/or has comparative advantage in that industry. Thailand and the Philippines, lacking a "national car programme", seem to shift their policies from ISI to EOI, and focus more on their cross-border corporation with foreign automakers, particularly Japanese ones. Governments have introduced various measures, such as tax reductions on imports and exports, lifting of restrictions on the import of P&C, liberalisation schemes and the removal of import bans and tariff protection for domestically manufactured products, to make their countries attractive for automotive investment. On the other hand, the Republic of Korea, Malaysia and Indonesia have implemented a different strategy from Thailand and the Philippines. Those three countries focus more on their "national car" model into which they have put very large resources directly or indirectly into the building of a single automobile company. In the case of Malaysia, a high import duty and local content policies have been imposed to protect the "national car", and a single manufacturer has also been encouraged. In the case of the Republic of Korea, the competition between automobile manufactures is kept under control.

[70]FDI into the automotive sector in Thailand has increased well over 15 percent between 2007 and 2009, and more than half of the FDI came from Japan (Asia Monitor Research Centre, 2011).

Similar to government policies and programmes, Japanese MNCs have also played a pivotal role in boosting auto trade in the East Asian region, as well as helping many countries in the region to develop their own automobile industry. In fact, these two factors may be complementary in that government policies facilitate FDI as necessary for the development of the automobile industry in East Asia. In addition, they are also considered one of the most important determinants in the development of East Asian countries' position in the international production chain of the automobile industry. In Table 6.6, we can see that in the case of export of auto P&C, variables $lFDI\_A_{it}$ and $lFDI\_B_{it}$ have a negative sign and are also significant, at least at 10 percent significant level. These results indicate that an increase in Japanese FDI outflows to developing East Asian economies would lead to a decrease in Japanese export of auto P&C worldwide.

In equations (6.9) and (6.10), we include interaction term between Japanese FDI outflow and DEA. Based on the interaction analysis, we can divide the impact of Japanese FDI outflow into two categories, i.e. its impact on the export of DEA's auto P&C (as well as final automobiles) and its impact on the export of Japanese auto P&C as a base category (final automobiles). Based on Table 6.7, we can see that from the export side of auto P&C, the interaction terms, $lFDI\_A_{it}$*$Ddea(x)\_W$ and $lFDI\_B_{it}$*$Ddea(x)\_W$, are statistically significant with a positive sign. These results indicate strong evidence in these data that the Japanese FDI outflow to DEA for both periods (i.e. 1990-2004 and 2005-2010) has had a different effect on the export of auto P&C from either Japan or DEA. Nonetheless, as indicated in Table 6.8, the magnitudes of the different effect in both periods are too small (i.e. 0.008 and 0.002 respectively). Therefore, we may conclude that when the outflow of Japanese FDI to

DEA increases, the export of DEA's auto P&C to the global market was not greater than the export of Japanese auto P&C worldwide. This finding is in line with Nishitateno (2012) who found that there is a complementary relationship between FDI and Japanese export of auto P&C.

Table 6.7: Summary Results for log of FDI_A_{it} and the Interaction Variables

Model		***Main effect of lFDI***	***Interaction effects****
Export	Auto P&C	- 0.229	-0.229 + 0.237 = 0.008
	Final automobiles	0.216 (insignificant)	Irrelevant due to the insignificant of interaction terms
Import	Auto P&C	0.066 (insignificant)	
	Final automobiles	0.352 (insignificant)	

*Note: (1) * Refer to the dummy of DEA (Ddea(x)_W = 1 if country i = China, Indonesia, Malaysia, The Philippines, Thailand and Vietnam, while = 0 if country i = Japan, Republic of Korea and Singapore.*

(2) In the import model the dummy of DEA is Ddea(m)_W

(3) FDI_A_{it} refers to the Japanese FDI to DEA between 1990 and 2004.

Table 6.8: Summary Results for log of FDI_B_{it} and the Interaction Variables

Model		***Main effect of lFDI***	***Interaction effects****
Export	Auto P&C	- 0.209	-0.209 + 0.211 = 0.002
	Final automobiles	0.573 (insignificant)	Irrelevant due to the insignificant of interaction terms
Import	Auto P&C	0.189 (insignificant)	
	Final automobiles	0.357 (insignificant)	

*Note: (1) * Refer to the dummy of DEA (Ddea(x)_W = 1 if country i = China, Indonesia, Malaysia, The Philippines, Thailand and Vietnam, while = 0 if country i = Japan, the Republic of Korea and Singapore.*

(2) In the import model the dummy of DEA is Ddea(m)_W

(3) FDI_A_{it} refers to the Japanese FDI to DEA between 2005 and 2010.

6.7 Conclusion

The objective of this chapter is to investigate empirically the factors that determine the level of automobile trade in East Asian countries, given their position in the international production chain. The study also attempted to employ and examine the importance of the summary measures regarding the nature of IPNs (namely, network

density and domination intensity indices), the role of government policies (i.e. ISI and EOI policies), as well as the impact of Japanese FDI outflows on the level of DEA's automobile trade.

The findings of this chapter contribute to a deeper understanding of the determinants behind the development of East Asia's IPNs in several ways. Firstly, apart from the economic size of the exporting and importing countries, distance, per capita income, relative labour costs, FTA, government policies, language, and FDI, we have now discovered that the network density, a country's dominating power and position in IPNs also play a significant role in determining the level of East Asia's trade in the automobile industry. In particular, a country with a high degree of trade integration with its trading partners in IPNs seems poised to increase its exports and imports of automobile products, and the same can be said of a country with a high dominating power in IPNs.

Secondly, we also discovered that network structure has an impact on determining the level of automobile trade when we take into account in our analysis a country's position in the IPNs. Specifically, even though both "middle" and "bottom" countries may serve as the main importer of auto P&C, the amount of auto P&C imported from their partner(s) may be different. For example, we found that "middle" countries such as Thailand and China import more auto P&C than "bottom" countries such as Malaysia and Vietnam. We believe this to be a result of "middle" countries importing auto P&C for export and domestic use, while "bottom" countries import these products for local demands only.

Thirdly, government policies, namely ISI and EOI strategies, have a significant impact on import and export, respectively. In particular, when ISI strategy is implemented, the import of final automobiles decreased, while its impact on the import of auto P&C was insignificant. Meanwhile, when EOI strategy is implemented, the export of both auto P&C and final automobiles increased. This is because many East Asian countries have set up investment-friendly incentives and policies such as tax holidays on corporate income, import duty exemption on intermediate products, land ownership rights for foreign investors, permission to bring in foreign experts and technicians, etc., in order to attract MNCs (particularly Japanese ones) to invest in their countries. In general, Japan's direct investment in East Asia has continued to increase over time. For instance, the total amount of Japanese investment in East Asia in 2004 was US$ 10.4 billion, and this figure jumped to about US$ 17.0 billion in 2008 (JETRO website[71]). Japanese investments in China and Thailand[72] were consistently high, while the other Asian countries have experienced increase in investment in a specific year, such as Malaysia in 2006, Singapore in 2007, and Republic of Korea in 2008 (Fumio and Heruhi, 2011).

Finally, we found that Japanese FDI outflows to DEA reduced export of auto P&C from Japan to the rest of the world. Meanwhile, we also found that Japanese FDI outflows to DEA have led to an increase in DEA's export of auto P&C worldwide. Nevertheless, this increase never seems to exceed the volume of Japanese export of the same products. This indicates that although Japanese MNCs have been instrumental in developing the automobile industry in many Asian countries (especially Thailand and the Philippines as production centres for its auto P&C),

[71]See http.//www.jetro.go.jp/

[72]Although Thailand experienced devastating flooding at the end of 2011, many Japanese automobile enterprises have announced their intentions to continue investing in Thailand in early 2012.

Japan is and remains the region's major exporter of these products. In other words, even though other East Asian countries have achieved rapid development of their automobile industry, they are still unable to compete with Japan in terms of the export value of auto P&C.

Annex to Chapter 6

Annex Table 6.1: Automotive Policies in East Asian Countries

Country	Duration	Policy
China	1990-1993	Period before the 1994 Automotive Policy
	1994-2003	Period after the 1994 Automotive Policy
	2004-2010	Period after the 2004 Automotive Policy
Indonesia	1990-1992	Period before the 1993 Auto Policy
	1993-1995	Period after the 1993 Auto Policy
	1996-1998	Period after the 1996 Auto Policy
	1999-2010	Period after the 1999 Auto Policy
Malaysia	1990-1995	Period within the First Industrial Master Plan (IMP)
	1996-2005	Period within the Second IMP
	2006-2010	Period within the National Automotive Policy (NAP)
The Philippines	1990-1995	Motor Vehicle Development programme (MDVP)
	1996-2001	Amended MDVP
	2002-2010	New MDVP
Thailand	1990-1995	Early liberalisation era
	1996-2002	Period after BCC/AICO
	2003-2010	Period after AFTA
Vietnam	1990-2002	Period before the structure of Vietnam auto industry approved
	2003-2010	Period after structure of Vietnam auto industry development approved

Annex Table 6.2: Correlation Matrix between Variables

	$lgdp_i$	$lgdp_j$	$ldis_{ij}$	$lpcy_i$	lpcyj	lyij	lrlc	lanij	fta	mid	bot	isi	eoi	nd	ldiix	lfdi_A	lfdi_B	Dea
lgdpi	1.00																	
lgdpj	-0.04	1.00																
ldisij	0.04	0.20	1.00															
lpcyi	0.42	-0.01	0.04	1.00														
lpcyj	-0.01	0.41	0.45	-0.00	1.00													
lyij	0.11	0.24	0.25	0.11	0.58	1.00												
lrlc	0.31	0.12	0.05	0.13	-0.18	0.29	1.00											
lanij	-0.26	-0.04	-0.09	-0.08	-0.09	-0.07	0.12	1.00										
fta	-0.07	-0.10	-0.61	-0.01	-0.32	-0.22	-0.01	0.12	1.00									
mid	0.08	0.07	0.01	-0.26	0.08	0.04	0.05	-0.04	0.04	1.00								
bot	-0.59	-0.01	-0.04	-0.31	-0.03	-0.10	0.09	0.24	0.05	-0.61	1.00							
isi	-0.32	-0.00	-0.07	-0.39	-0.02	-0.07	0.11	0.13	0.01	-0.34	0.58	1.00						
eoi	0.32	0.01	0.02	-0.00	0.03	0.07	0.01	-0.09	-0.04	0.30	-0.50	0.41	1.00					
nd	0.67	-0.01	0.03	0.29	0.00	0.11	0.13	-0.17	-0.04	0.21	-0.49	-0.25	0.32	1.00				
ldiix	0.64	-0.01	0.06	0.53	0.02	0.14	0.21	-0.25	-0.05	0.21	-0.65	-0.51	0.51	0.61	1.00			
lfdi_A	-0.01	-0.21	0.00	-0.14	-0.16	-0.14	0.02	-0.07	-0.20	-0.28	0.15	0.07	-0.05	-0.07	-0.10	1.00		
lfdi_B	0.09	0.21	-0.00	0.11	0.17	0.15	0.08	0.03	0.20	0.33	-0.20	-0.12	0.11	0.12	0.17	-0.58	1.00	
Dea	-0.65	0.09	-0.03	-0.55	0.07	-0.08	0.11	0.15	0.11	0.23	0.34	0.21	-0.17	-0.64	-0.65	-0.21	0.19	1.00

CHAPTER 7 : CONCLUSION

7.1 Introduction

This chapter has the following structure. Section 7.2 summarises and synthesises the empirical findings across all of the empirical chapters. Section 7.3 sets out a number of policy implications. Section 7.4 discusses the thesis' limitations and offers suggestions for future research.

7.2 Key findings of the thesis

The development of East Asia's economies has followed a remarkable pattern, unlike developing economies in other parts of the world. In East Asia, country by country, at different stages of development, has realised economic growth by participating in a dynamic production network created for the most part by private foreign firms. Linked by trade and investment, a system of international division of labour with a clear order and structure exists in the region. Under this system, industrialisation has proceeded by means of geographic expansion and structural consolidation within each country. In other words, for developing countries to achieve economic development, they needed to become one of the crucial links in a production network that is under competitive pressure and cooperative relations with neighbouring countries. In the context of East Asia, this study explores the structure, nature, and determinants of this phenomenon in terms of the automobile industry. The findings

of this thesis constitute its major contributions, as clarified in the objectives set out in Chapter 1.

7.2.1 Identifying the structure of IPNs

The first contribution of this thesis is to develop methods for identifying the structure of IPNs in the automobile industry, as characterised by vertical specialisation. In this hierarchical structure, countries are arranged vertically, with some occupying the top position (i.e., either complex-advanced top, simple-advanced top or basic top) while others occupy the middle (i.e., either advanced middle or basic middle) or the bottom position (i.e., either advanced bottom or basic bottom). As expected, Japan consistently occupied the top position from 1990 to 2010. Specifically, it improved its position from simple-advanced top (1990-1995) to complex-advanced top (2000-2010). Interestingly, the Republic of Korea seems to improve its position almost every five years. In 1990, the Republic of Korea's position was characterised as "advanced-middle". Five years later, its position changed to "basic top". Subsequently, in 2000 and 2005, its position improved to "simple-advanced top" and "complex-advanced top", respectively. Meanwhile, Thailand improved her position dramatically from "advanced-bottom" (1990-1995) to "advanced-middle" in 2000 and 2010. China improved its position from "advanced-bottom" (1990-1995) to "basic-middle" (2000-2010), while the Philippines improved its position from "advanced-bottom" (1990-2000) to "basic middle" in 2005. In the case of Malaysia and Singapore, both countries consistently occupied an "advanced-bottom" position throughout the period under study. Meanwhile, Vietnam improved its position from "basic bottom" (between 1990 and 1995) to "advanced bottom" (between 2000 and 2010).

Indeed, the above findings add to the existing knowledge on the issue (e.g. Kasahara, 2004; Kimura, 2006; Kimura, 2007) by highlighting that there exist hierarchical relationships between countries in East Asia with specifically stating which one occupies which position. Moreover, the above findings have also indicated that industrial development with respect to East Asia's automobile industry follows more or less the theory of the flying geese (in line with Kojima, 2000; Ozawa, 2010; and Kasahara, 2004) and the spiral development hypothesis. In this catch-up process, we have observed that Thailand has grown to be one step ahead in producing automobile products, compared to other East Asian countries. Meanwhile, China, Indonesia and the Philippines have started to produce auto P&C that were previously imported from Japan, while a latecomer, namely Vietnam, has begun to follow ASEAN and China's footsteps. The rising levels of competitiveness in these countries' auto industry are due to government policies, inward FDI into those countries (Kwan, 2002), as well as the key roles played by Japanese MNCs.

In terms of theoretical implication, the above findings also indicate that the theory of fragmentation (which states that the production process is divided into several stages and that these processes take place in various locations) seems applicable to the East Asian automobile industry. In addition, the findings also support the notion that intra-industry trade in East Asia's auto industry is vertical rather than horizontal – as argued by Kimura et al. (2006; 2007). In this respect, Japan and the Republic of Korea have emerged as the leading countries occupying top positions in the chain, while other East Asian countries occupy the middle (e.g. Thailand and the Philippines) and bottom (e.g. Vietnam). In this vertical relationship, Japan played a major role in the transformation of the industry during this period, for it now imports

auto P&C from its East Asian partners and exports them to Thailand to sell as final goods. Korea has also followed in Japan's footsteps but with the focus on developing the industry in Vietnam and China.

The structure of East Asia's automobile production networks also indicates that development in leading countries' (i.e., Japan and Korea) automobile production networks has been influenced by development in their subordinates' automobile industry and vice versa. This suggests that there exists a certain economic complementary within the East Asia region between developed economies (i.e., Japan and the Republic of Korea) and developing economies (ASEAN and China) – all of which benefit both parties. In this respect, Japan and the Republic of Korea have taken advantage of the rapid development and growth in East Asian developing economies, not to mention the proliferation of free trade agreements in the region (e.g., ASEAN+3) which leads to the expansion of intra-East Asian trade. In addition, the development in the automobile industry of China and ASEAN has resulted in demands for capital goods and technology from Japan and the Republic of Korea going up, and this situation leads to an increase in aggregate demand and consequently further economic growth for Japan and the Republic of Korea. Due to this positive impact, Japan and the Republic of Korea should seize the opportunity to promote a region-wide East Asian economic cooperation which could shape the economic future of East Asia.

Since economic interdependence within East Asia has led to rising trade and capital flows, we could say that "deep" and continued collaborations between the leading countries and their subordinates are important for the expansion of regional automobile production networks as well as vertical trade among East Asian

countries. In this respect, Japan and the Republic of Korea should assist their subordinates and perhaps even other developing East Asian countries to expand their automobile industry as well, for example, through technological aid, technical expertise, FDI, etc. At the same time, subordinate countries (such as Thailand, China, and Vietnam) and other East Asian developing markets should provide a more conducive environment that will encourage the involvement of these two leading giants in their auto industry's development. In this respect, subordinate and other East Asian countries must liberalise to a great extent by dismantling all kinds of trade barriers (i.e., tariff and non-tariff such as import and export licenses, local content requirements, import quotas, and trade restrictions). In addition, subordinate and other East Asian countries should also improve certain policies (for example, by applying "deep-integration" in trade agreements that would give an important signal to investors of their commitment to policy liberalisation) as well as providing better infrastructures such as more efficient ports, railways, roads, reliable internet and telephone access, and greater access to finance.

7.2.2 Measuring the nature of IPNs

The second contribution of this thesis is to develop summary measures of the characteristics of IPNs so as to ascertain the nature and development of these IPNs over time. Based on findings in Chapter 5, the East Asian automobile networks are becoming complex as more countries actively take part in those networks. As the most integrated country in the East Asian region, Japan has unsurprisingly emerged as the key player in auto parts, components, and final automobiles. This finding supports the argument by Shimokawa (2010) who pointed out that about 90 percent of East Asia's domestically produced cars have been made possible through

cooperation with Japanese firms. In addition, our findings show that Japan has consistently been the most powerful dominator, as many countries rely on her for auto products. Moreover, since 2010, Thailand seems to be following in Japan's footsteps to become the second most important player in auto parts, components and final automobiles. Apart from these two countries, the Republic of Korea and China have also become key players in this industry, with the former focusing on final automobiles while the latter focuses on auto P&C. Furthermore, the rapid development in the automobile industry of Thailand, the Republic of Korea, and China has given them all a certain degree of dominance.

In addition, the findings from chapter 5 also indicate that the automobile production network continues to grow. This shows that vertical trade between leading and subordinate countries in East Asia is expanding steadily. Thus, being part of and remaining within the international production chain and being able to better exploit the existing and emerging comparative advantages is important for each East Asian country in terms of achieving magnified economic growth. Also, specialisation (in stages) would lead to small countries becoming more competitive in producing certain products, and enjoying a larger share of total trade. In addition, East Asian countries should also implement wider reforms that are favourable to an export-led development (e.g., competition policy and intellectual property rights).

7.2.3 Important determinants of East Asia's automobile trade

The third contribution of this thesis is to employ summary measures (indices) as additional explanatory variables (as well as government policies and the role of Japanese FDI in augmented gravity models) in order to examine the determinants of

automobile trade levels among East Asian countries, given their position in IPNs. Specifically, Chapter 6 examines whether summary measures of structure and nature of IPNs, the role of government policies, as well as the role of Japanese FDI have become the main contributors to East Asian countries' trade in the automobile industry.

The findings of this analysis contribute to the existing literature on the determinants of IPNs in several ways. First, apart from variables in the conventional gravity model, the structure and nature of the IPNs themselves are also significant factors that determine the level of automobile trade in East Asia. These findings have actually filled a gap in the existing literature on determinants of IPNs in East Asia, such as found in studies by Athukorala and Yamashita (2006), Kimura et al. (2007), and Shepherd (2010), all of which exclude those factors. We envisage that East Asia's existing structure of IPNs in the form of vertical trade (top, middle, and bottom positions) with different countries has played a different role, causing them to exert different effects on trade. In addition, we also found that countries had different positions but played the same role. In this respect, "middle" and "bottom" countries, who played the role as importers of auto P&C, imported a different amount of auto P&C from their partner(s). For example, Thailand (as a "middle" country) imported more auto P&C from its trading partner(s) compared to Malaysia (a "bottom" country). This is because Thailand used those imported products to make cars for export as well as to meet local demand. In contrast, Malaysia used those products to make cars for local purposes only. In terms of the nature of IPNs, we found that a country with a high degree of trade integration with its trading partners in IPNs will be able to increase its export and import of automobile products, so is any country with a high dominating power in IPNs.

Second, we found that government policies, particularly ISI and EOI strategies, have a significant impact on import and export, respectively. In this respect, government policies relating to the industry are deemed geared towards supporting and encouraging the development of the automobile industry in the region. For example, the EOI strategies carried out by the Chinese government in providing facilities such as cheap infrastructure, free trade zone, duty rebates, etc., have led to a rapid expansion in the export of manufactured P&C between 2001 and 2005. The share of those products in total exports was well over 58 percent in 2005 (Shafaeddin and Pizarro, 2007). Meanwhile, one of the region's largest population, i.e. Indonesia, has begun to implement policies that promote the production and sale of low-cost vehicles for the purpose of maximising growth for the auto parts and final automobiles manufacturing industries. At the same time, countries such as Malaysia, the Philippines and Vietnam are looking for growth strategies to ensure the survival of their automobile industry. Meanwhile, the Republic of Korea is implementing the policy of expanding overseas markets as well as focusing on the development of environmentally-friendly vehicles, such as electric and hybrid cars.

Japan and the Republic of Korea shifted from ISI to EOI in the early 1960s and early 1970s respectively, while Southeast Asian countries shifted from ISI to EOI in the mid-1980s. Interestingly, the EOI implemented in each East Asian country involved the division and collaboration of labour in the vertical chain within and between regions. At the same time, cooperation and integration also took place among different countries in the region.

Third, in this study, we found that Japanese FDI to developing East Asian economies has had a significant impact on the export of auto P&C from those countries. Apart from internal factors (such as loss of competitiveness re producing automobile at home), Japanese FDI into East Asian countries began in the mid-1960s, mostly owing to external factors (such as protectionist policies imposed by importing countries, trade friction imposed by the United States and EU, liberalisation policies towards FDI, favourable economic performance in developing countries, advantages of carrying out production in proximity of the market, as well as FDI promotion policies carried out by the recipient countries). Many East Asian developing economies carried out FDI promotion policies in the hope of achieving continued economic growth by speeding up the process of structural change (Urata, 1993) as well as by expanding export performance. In addition, Japanese FDI also brings in valuable technology, management know-how, knowledge spillovers, financial resources and expertise which are important in the development of high-tech sectors as well as creating job opportunities. This situation has led to the automobile industry in many East Asian countries such as Thailand and China achieving rapid development and even becoming hubs of automobile production for export purposes. Even though Japanese FDIs have expanded exports of auto P&C in DEA countries, the increase in DEA's exports of auto P&C does not exceed the increase in Japanese export of those products. This indicates that although Japanese MNCs have helped develop the automobile industry in many Asian countries (especially Thailand and the Philippines as the centre of production for its auto P&C), Japan is and remains the region's major exporter of these products.

7.2.4 Summary of the key findings

Based on the key findings discussed in sub-section 7.2.1 to 7.2.3, one can conclude that the different level of development between countries across the East Asian region has led to the East Asian automobile production networks having a hierarchical shape. Countries who occupied top position of the hierarchy (such as Japan and the Republic of Korea) have strengths in terms of technology, capital and expertise which allow them to make their own cars, while countries who occupied the middle and bottom position lag behind in terms of technology, capital and expertise and thus have to rely on the top countries for those advantages. The dependency of middle and bottom countries on the top countries in terms of capital, technology and expertise, as well as the exploitation of resources (notably cheap labour) in the middle and/or bottom countries by the top countries to make profit create a certain regional integration among them. This integration relationship, in turn, allows the top countries to have dominating power over their trading partners. This situation seems to envisage the occurrence of "a new form of colonialism" by the top towards the middle and bottom countries in the East Asian region.

At the same time, middle (such as Thailand and China) and bottom (such as Vietnam) countries have different but complementary comparative advantages (such as cheap labour and/or technological level) that are needed by Japanese firms to construct a hierarchical division of labour based on different but complementary factor endowments. In this respect, Japanese firms try to distribute production activities among East Asian countries according to their level of technological know-how. Toyota, for example, used its affiliate in the Philippines as a base for specialised production of transmissions, its affiliate in Indonesia for gasoline engines, its affiliate in Malaysia for steering gears and electronic components, and its

affiliate in Thailand for diesel engines and pressed parts. Ultimately, it involves swapping auto P&C that are produced in larger quantities at specified factories across the East Asian region, and then assembling them as finished automobiles.

Since the early 1990, interconnection among countries in the East Asian region has continued to grow over time which reflects the rapid development of IPNs in this region. This development among others was encouraged by the tendency of many countries in the region to implement export-oriented and FDI-driven strategies. In this respect, countries in the top tier have played an important role through the free trade agreement platform in influencing other countries in the region to shift their current ISI policy to that of EOI. This is due to the fact that under EOI policy, countries' location advantage can be enhanced so as to meet the need of MNCs to make profit in their operations. For example, Japanese MNCs may decide to invest in a country that has location advantages such as better infrastructure, removal of restrictions regarding entry and operations of foreign firms, lower lending rates, higher labour productivity, and lower tariff rates.

7.3 Policy Implications

As stated earlier, there exists in the automobile industry a hierarchy that breaks up East Asian countries into three groups (i.e., top, middle, and bottom), and these groups are interdependent through the flow of goods. In this section, we are going to suggest some policies for top, middle, and bottom countries with a view to improving the value added from IPNs.

For the top countries (i.e., Japan and the Republic of Korea), they need to evaluate the investment climate in developing countries before deciding to invest in any of those countries. In this respect, they should consider investing in developing countries that are attractive in terms of cost of labour, market size and prospects for growth, political and economic stability, predictable rules for investment and a legal framework, availability of infrastructure, stability of the tax system, and productivity of labour. Countries with only the advantage of cheap labour or a large local market may not necessarily be attractive for investment if there exist a deficient infrastructure (road, electricity and telecommunication), high financing constraints, weak institutions, and lack of skill labour as in some developing countries. In other words, a long checklist of location advantages and service links must be prepared by top countries in order to improve their value added from IPNs.

Besides, for the purpose of cost reduction, production expansion and investment efficiency, top countries should select certain operations that need to be moved to a new location. The differences in terms of location advantages that exist in the network should be exploited in order to gain profit from the IPNs. For example, the presence of a large pool of skilled labour at affordable cost in Thailand should be taken advantage of by top countries to produce diesel engine and body panel, while cheap unskilled labour in Vietnam should be exploited to produce simple manufacturing products such as wire harness and wiper arm.

At the same time, top countries should also expand negotiation over FTAs to encourage host countries (especially middle and bottom countries) to reform their policies in favour of creating an IPN-friendly environment. In this manner, firms in

the top countries must be more active in efforts to improve the business environment in the East Asian region.

For the middle countries (i.e., Thailand, China, the Philippines, and Indonesia), flexible and supportive policies that align with the interest of firms from the top countries should be expanded to a greater extent. This is important because firms from top countries such as Japan were crucial in bridging productive resources among countries and facilitating industrialisation as in bringing capital and technology into the host countries. In this respect, middle countries should not only offer fiscal incentives such as exemption or reduction in import duties and corporate income tax, but should also offer a range of non-tax incentives for investment based on location such as permission to bring in foreign workers, owning land, and taking or remitting foreign currency abroad. In addition, foreign businesses should be entitled to a 100-percent foreign ownership. This attractive incentive is important to attract firms from top countries to expand their operations in the middle countries. As a result, this action would lead to improvement in the middle countries' dynamic comparative advantage and in turn would bring further development to the middle countries' automobile industry.

In order to avoid lagging behind, bottom countries (i.e., Malaysia, Singapore, and Vietnam) should participate actively in the automobile production networks, just as they have done in their electrics and electronics industry. This is because participation in IPNs is very critical to expanding their export of automobile products. To do so, bottom countries should invite export-oriented foreign companies by providing them with a world-best location advantage. In this respect, bottom countries should eliminate or reduce trade and investment barriers in the auto

industry, enhance human capital skills, and improve technological advancement in communication. In addition, local firms in bottom countries should also engage themselves in exporting activities that are within IPNs.

7.4 Thesis' limitations and suggestions for further research

Inevitably, there are certain limitations to a thesis of this nature. Firstly, due to a lack of data, we faced certain problems when it came to obtaining data for the value of domestic auto P&C, as well as for final automobiles produced and sold within the countries under study. Therefore, in analysing East Asia's automobile production networks, we were unable to conduct a comprehensive analysis since we were unable to take into account any domestic activities such as domestic sales of final automobiles and domestic sales of auto components and parts. In addition, owing to the lack of data, we were also unable to include Taiwan in our analysis. However, this is not a significant omission. Further, the cut-off point of 15 percent used in our analysis in Chapter 4 is somewhat arbitrary. Nonetheless, to ensure the reliability of the analysis, we have conducted some sensitivity analyses as well. Based on those analyses, the 15 percent cut-off point that we chose in this study is proven robust.

This empirical study also provides some suggestions for further research. Firstly, IPNs have existed in East Asia in a number of industries such as electric and electronics, computer, automobile, garment, etc. And since the focus of this study is confined to the automobile industry, it would be interesting if similar research could be extended to other industries. Research in other industries will allow us to capture the nature and patterns of vertical specialisations in those industries. Besides, a comparative study of trade patterns between industries including automobiles can

thus be made. Secondly, since the scope of our study focuses on countries in the East Asian region, the role and position of another important auto production base, namely India, are yet to be determined. According to Hiratsuka (2008), India has started to become the focus of Japanese MNCs which have played a role in the development of IPNs, hence that country will also be integrated into East Asia. Moreover, Japan and India have started to negotiate an Economic Partnership Agreement (EPA) in 2007, and intensive talks have continued. Therefore, for further research, it would be interesting to include India in a study of East Asia's automobile production networks, in which the roles and linkages of that country to other East Asian countries such as Thailand can be observed.

Thirdly, IPNs are believed to bring benefits to participating countries. For example, shifting production activities from developed to developing countries would benefit host countries in terms of job creation, knowledge and technology transfer, promoting economic growth, and so forth. Nevertheless, IPNs' activities could also create negative effects such as negative externalities. Therefore, it would be a worthy topic for further research to investigate the effect(s) of externalities from IPNs on the host countries.

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